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IN TWO SECTIONS—SECTION ONE

MECHANICAL ENGINEERING

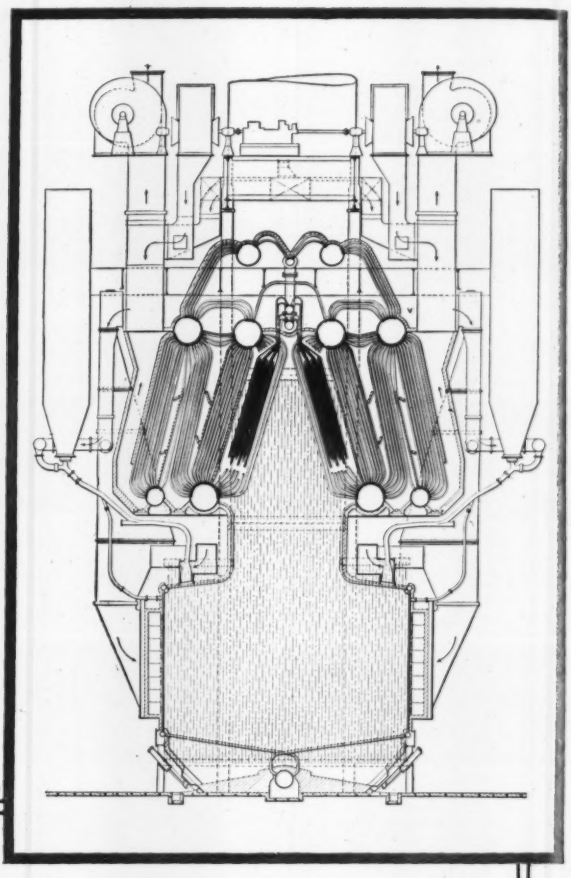
UNIVERSITY OF

Railway Tunnel Electrification

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

September 1930

A Million pounds of Steam per hour at 86.5% efficiency



HEAT BALANCE of
No. 7 BOILER OUTPUT 1,000,000 lb. per hr.

	B. t. u.	*Per cent*
Loss due to moisture in coal	11	0.1
Hydrogen	453	3.0
Dry chimney gases	1,137	7.7
Combustible in refuse	73	0.5
Moisture in air	30	0.2
Radiation and unaccounted for	294	2.0
Total losses	1,998	13.5
Efficiency and heat to boiler	12,772	86.5
Total	14,770	100.0

Boiler unit No. 7 is one of three Combustion Engineering Steam Generating units installed in the East River Station of The New York Edison Company.

This heat balance shows the results of a twelve hour test run, where evaporation averaged 1,000,000 lb. per hour. For peaks, this unit has operated at the rate of 1,270,000 lb. per hour.

The above heat balance is from a paper presented at the Summer convention of the A.I.E.E., Toronto, Ont., Canada, June 23-27, 1930,—by C. B. Grady, Mechanical Engineer, W. H. Lawrence, Chief Operating Engineer, and R. H. Tapscott, Electrical Engineer, of The New York Edison Company.

The Coal used in test of No. 7 Boiler:

Proximate Analysis (dry basis)

Volatile	21.5 per cent
Fixed Carbon	72.4 per cent
Ash	6.1 per cent
B.t.u.	14,770.
Sulphur	1.4 per cent

(Moisture in coal as fired—1%)

COMBUSTION ENGINEERING CORPORATION

200 Madison Avenue **New York, N. Y.**

BOILERS - AIR PREHEATERS - STOKERS - PULVERIZED FUEL EQUIPMENT - WATER-COOLED FURNACES

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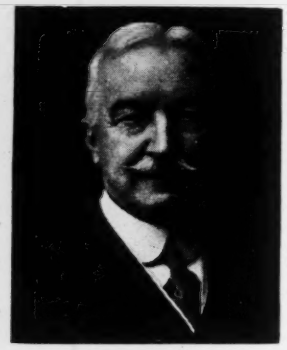
The Engineer in National Affairs



AS I vision the future, the engineering profession must inevitably take upon itself more and more of the responsibility of management of the affairs of our country, which has come into its position of major influence among the nations almost wholly because of its achievements in engineering. That engineers are aware of this fact is evidenced by the broadening scope of their activities in less technical fields than those which have for fifty years absorbed most of their interests and attention. What the world needs today is the habit of straight and honest thinking from cause to effect. That, perhaps, is the engineer's most valuable attribute.

MORTIMER ELWYN COOLEY

MECHANICAL ENGINEERING

Volume 52 September, 1930 No. 9

Economics of Railway Electrification

Extent of Field in Which Electrification Is Economically Warranted—Savings Obtainable Through Electrification—Electrification Work Now Under Construction—Performance of Existing Steam-Railway Electrifications

By R. B. MORTON,[1] NEW YORK, N. Y.

ELECTRIFIED railways in the United States now comprise nearly 1900 miles of route, which is about 3/4 of 1 per cent of the total of 250,000 miles of steam railways in the United States. While this is not a very impressive total, it should be noted that electrification has in general been undertaken on routes favored with a traffic of more than average density. It would seem, therefore, that a more suitable yardstick would be work performed. This work obviously consists in the movement of passenger and freight trains, and might be expressed in terms of horsepower-hours developed at the drawbar of the locomotive, but as this would be impossible to determine, it is preferably expressed in gross ton-miles of trailing load.

Historical

The electrification of steam railways in this country dates from 1895, when the Baltimore tunnel of the B. & O. Railroad and the Nantasket Beach Branch of the New Haven Railroad began electric operation, the former using electric locomotives and the latter using motor cars.

No other electrifications of importance were undertaken in the following decade, but beginning with 1905 there has been rather consistent progress, interrupted for some five or six years during the war and post-war periods. Since 1923 the work of electrification has proceeded at an average rate of about 200 track-miles per year, the present total of track-miles electrified being about 4200, on which there are used some 465 electric locomotives and 2750 multiple-unit cars. Judging from the mileage of electrifications now under construction and of projects authorized or announced, it seems probable that electrification will go forward during the next decade at a more rapid rate.

Reasons for Electrification

The compelling reasons for most of the electrifications thus far undertaken in this country have been one or more of the following circumstances:

a Legislative enactment
b Smoke relief in tunnels
c Congestion of terminals, where enlargement of terminal facilities have been prohibitively expensive
d To make possible the construction of new underground terminals, where air rights for over-building may be extremely valuable
e Congestion of routes because of large volume of traffic at slow speed on heavy grades, where the construction of additional main tracks would be very expensive; and
f Economic considerations.

In many of these electrifications it was not reasonably to be expected that direct operating savings due to electric operation would be sufficient to show a fair return on the net cost of the electrification.

Progress in Europe

In Europe the situation as regards railway electrification has been somewhat different. In Switzerland, Italy, and Sweden, for example, a total of about 3300 miles of route have been electrified, constituting more than 10 per cent of total mileage of railways in those countries. Each of these countries has a plentiful supply of water power, but no domestic coal resources. It has therefore been quite natural for them to go in for extensive electrification programs as a matter of national policy in reducing their requirements of fuel imports.

Gas-Electric Rail Cars

Coming back to conditions in the United States, many of our important railway systems have been making considerable use of gas-electric rail cars, particularly in their branch-line services where passenger traffic is comparatively light. According to a recent report of a Committee of the A.E.R.E.A., there are now about 1000 cars of this type in operation in this country. Claims have sometimes been made that the self-propelled cars are real competitors of railway electrification. As a matter of fact, however, any service in which these cars can show satisfactory operating economies as compared with the steam-train operation

---

[1] Project Engineer, Gibbs & Hill. Fellow A.I.E.E. Mr. Morton was graduated from the University of Vermont in 1899, and from the Massachusetts Institute of Technology in 1901 with degree of S.B. in E.E. He was with L. B. Stillwell, New York, as assistant engineer in the electrification of the Hudson & Manhattan Railroad; design and construction of the Hauto steam power plant; electrification of Hoosic Tunnel; and appraisal of several electric-railway properties. Since 1923 he has been associated with Gibbs & Hill in the electrification of the Virginian Railway, New York Connecting R.R., Long Island R.R., Bay Ridge Division, and the Pennsylvania Railroad, Philadelphia Suburban and Philadelphia-New York main line.

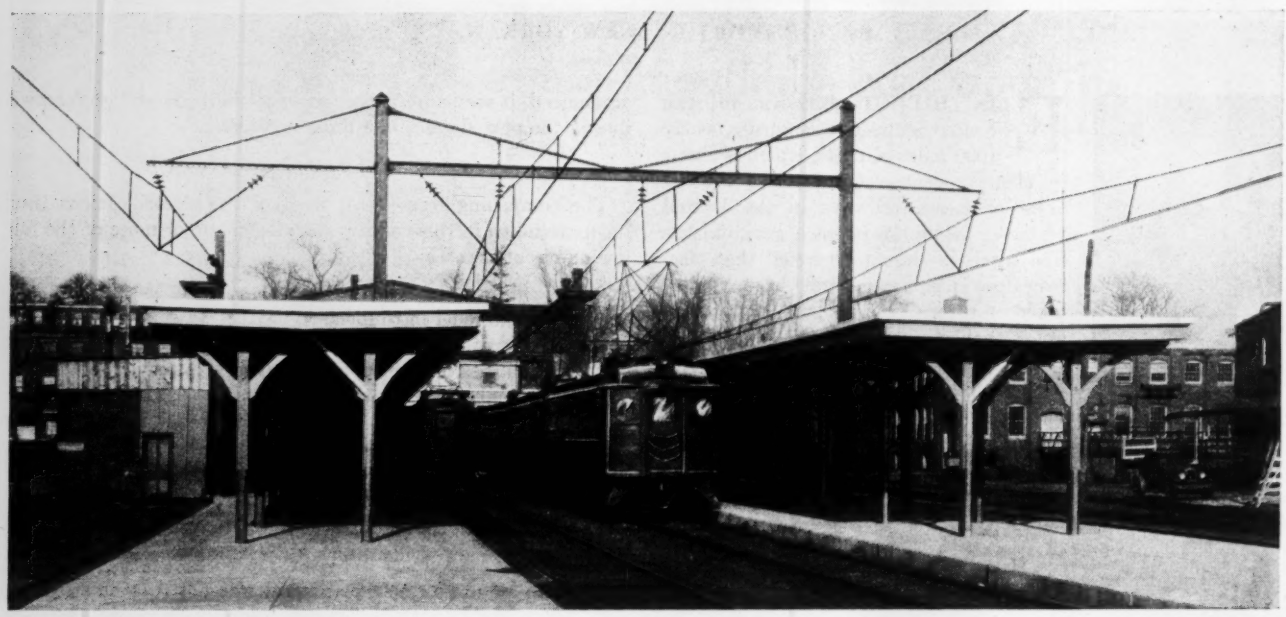
Presented at a meeting of the Bridgeport Section of the A.S.M.E., February 13, 1930.

which they displace, would not have traffic density sufficient to justify electrification. These self-propelled cars may in some cases prove to be of real advantage to an electrification program in serving as efficient feeders to an electrified main line, thereby avoiding the necessity of an unprofitable appendage to the main-line electrification.

Diminished Field

During the past 15 years certain factors have developed which have had a tendency to diminish the field in which the electrification of steam railways may be undertaken with reasonable prospect of economic return on the investment. The principal factors are, briefly,

a Improvements in the steam locomotive
b Increase in cost of electrification
c Decline in passenger traffic.



Station at West Chester on Pennsylvania Electrification

Steam-Locomotive Improvements

Discussing these factors in the order mentioned: Steam locomotives have been greatly improved in fuel economy by the application of superheaters, feedwater heaters, stokers, brick arches, and other refinements. Evidence of this appears in a recently published report of a committee of the American Railway Association, which gives the present average fuel consumption in freight service per 1000 gross ton-miles as 127 lb., as compared with 170 lb. in 1920. This represents a decrease of slightly more than 25 per cent. Of course, these improvements have as yet been applied to only a relatively small proportion of all steam locomotives now in use, and as application of such improvements is further extended, a corresponding further improvement in fuel economy is to be expected. It is claimed that the best steam locomotive of today—well described as "full jeweled"—can perform 1000 ton-miles of service with about one-half the fuel consumption of the locomotive of ten years ago. There has also been a progressive increase in weight and tractive power of both freight and passenger locomotives, enabling them to haul heavier trains. The application of stokers has increased their steaming capacity as well as their fuel economy, and has made it possible to cover much longer runs and at higher average speed. The effect of this is to produce a greater mileage per locomotive per year. The net result has been that for the year 1928, the total train-miles, train-hours, and tons of fuel consumed in freight service had shown an actual decrease as compared with the figures for 1920, in the face of a 21-per-cent increase in volume of freight service.

Cost of Electrification

The cost of electrification construction has increased very considerably in the past 12 or 15 years, both as to labor and materials. Over all, this increase has probably amounted to at least 100 per cent. Obviously the effect of this increased cost is to eliminate many an electrification project from the list of those which a few years ago would then have been economically justifiable.

Decline in Passenger Traffic

Coordinately with the amazing increase in the number of automobiles and the improvement of highways reaching to every part of the country, there has been a startling slump in volume of rail-passenger travel. The number of revenue passengers carried appears to have reached a peak in 1920, and since then has progressively declined. The figures for the year 1928 indicate a loss in volume of about 33 per cent as compared with 1920. It is therefore quite problematical how much further this loss will continue. More automobiles bring more paved roads, and more paved roads bring more mileage of automobile travel, year by year.

Competition of Aircraft

During the past year or two the airplane has apparently made its modest entry as a common carrier of passengers, mail, and high-class package freight. Who is there so bold as to venture an estimate of the possible growth of travel by aircraft in the course of the next decade? And how much of this new mode of transportation will represent loss to the railways in passenger travel?

Greater Returns From Freight

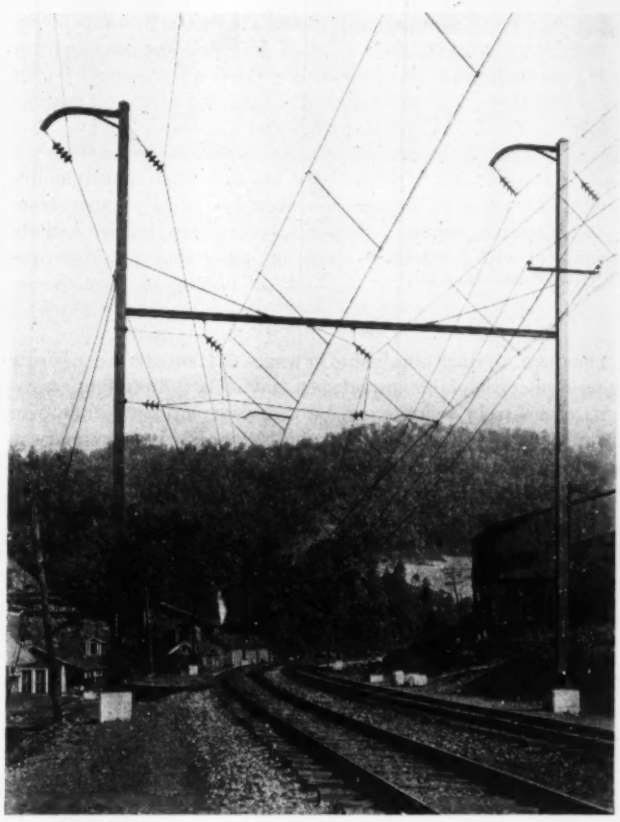
As an antidote to all this seemingly pessimistic outlook for the future of railway passenger business, let it be noted that the operating savings to be realized from the electric haulage of freight

traffic are usually much greater than those to be had in passenger service, and that freight traffic as measured in ton-miles carried by American railroads is not on the decline, but on the average is increasing. The growth since 1920 has amounted to about 21 per cent.

It has been said that 90 per cent of the total railroad traffic of the United States is handled over about 10 per cent of the trackage, and electric traction is making itself felt on this 10 per cent. The significance of this is that the average traffic density on the 10 per cent is something like 80 times greater than the average for the remaining 90 per cent. If these figures are correct, it is fairly evident that the economic field for electrification lies mostly in the 10-per-cent zone.

TRAFFIC DENSITY

The first cost of electrification is for the most part proportional to track mileage equipped, and is to a much lesser extent dependent on volume of traffic moved. Operating savings due to electrification are, of course, in nearly direct proportion to volume of traffic. It therefore follows that for any given electrification there must be some point of traffic density at which electrification is economically justified. There are, however, in most electrification projects many special conditions which may affect the operating savings to be realized by electrification, as well as the added annual cost chargeable to the change from



OVERHEAD CONSTRUCTION ON CURVE OF NORFOLK AND WESTERN

steam to electric operation. It is therefore unsafe to generalize on the volume of traffic necessary to justify an electrification economically.

BRANCH LINES

Generally speaking, the electrification of a branch line carrying a relatively light volume of traffic, when added to a heavy-traffic main-line electrification, will not show operating savings in sufficient amount to justify the added capital expenditure. There are, however, some instances where the electrification of light-traffic branches is desirable in order to avoid the many operating disadvantages which are associated with a change of power at the point where the branch line joins the main line. In many cases these disadvantages may be overcome in large measure by the use of self-propelled rail cars or oil-electric locomotives. As before mentioned, this has already proved an attractive field for these types of motive power, and bids fair to become of increasing importance in the future as their reliability and economy become

CURVE CONSTRUCTION WITH 88,000-VOLT TRANSMISSION ON VIRGINIAN RAILWAY

more convincingly demonstrated and first costs are lowered by quantity production.

STEAM-LOCOMOTIVE MAINTENANCE

One of the most important items in direct operating savings is to be found in locomotive maintenance. It is insufficient to compare the cost of maintenance of steam locomotives and of electric locomotives on the basis of locomotive-miles; a better measure is on the basis of mileage equated for weight on the drivers. The figures for steam-locomotive repairs, obtainable from annual reports, are not of much value for such a comparison, for the reason that such costs are not usually separated as to class of locomotive or kind of service performed. The costs in which we are interested for purposes of comparison are also usually obscured by the fact that some, but not all, of the locomotives have been modernized by the application of refinements already mentioned, for the purpose of increasing their output and improving their economy. These refinements naturally increase the cost of locomotives repairs by a very considerable amount, even though such refinements may be more than justified by improved fuel economy.

ELECTRIC-LOCOMOTIVE MAINTENANCE

Statistics covering the cost of electric-locomotive maintenance for all of the important steam-railway electrifications in this country, and covering in most cases the entire period of such operation, indicate that these costs have fluctuated widely for different railroads from year to year, affected by age of locomotive, kind of service performed, including speed, frequency of stops, severity of grades, loads hauled, average daily mileage, effects of deferred maintenance, changing price levels for materials and labor, etc. A weighted average of figures obtainable,

covering a period of the three years, 1926, 1927, and 1928, indicates approximately 16 cents per mile per 100 tons on drivers.

SAVING IN MAINTENANCE

Where an electrification covers only a part of an engine division of the railroad's system, it may be expected that electric-locomotive mileage will be very nearly equal to the steam-locomotive mileage which it displaces. But when one or several entire engine divisions are covered, the general effect may be practically to abolish the ruling grade imposed by the limit of steaming capacity of the steam locomotive. Advantage may be taken of this by operating fewer trains of greater weight. Although the electric locomotive is limited in the maximum tractive force that it can exert in starting a heavy train to approximately the same percentage of total weight on drivers as a steam locomotive, the electric locomotive does not have to be de-rated for low temperatures and bad weather conditions. Consequently a considerably greater annual ton-miles of service can be performed per locomotive-mile by the electric than by the steam locomotive, assuming weight on drivers to be the same in both cases. The net result is that, on the basis of equal performance, there is a very large difference in cost of repairs in favor of the electric locomotive. In a number of cases analyzed for divisional operation, the ratio of cost for steam- and for electric-locomotive repairs has been of the order of three to one.

LOCOMOTIVE FUEL

Another important item for comparison is that of fuel for the steam locomotive versus cost of electrical energy. As already noted, the average fuel consumption of the steam locomotive per 1000 ton-miles has in the past eight or ten years been reduced something like 25 per cent, with further improvement in prospect as a greater proportion of locomotives are equipped with devices for reducing their fuel consumption. The cost of this item is made up of the cost of the coal at the mine, plus transportation and handling to the various coaling stations. If the transportation happens to include a haul of considerable distance over other railroads, the delivered cost per ton may in some cases be more than double that for a road which has only a short haul from the mines over its own rails.

ELECTRIC POWER SUPPLY

When a railroad contemplates an electrification project it is faced with the question: Shall power be purchased from one or more public utilities, or shall the railroad construct and operate its own power plant? The decision rests mainly with the utility, whether or not it can offer a long-term contract to supply the power requirements of the railroad at a rate low enough to meet the competition of any power plant that the railroad might construct, including suitable annual charges for interest, taxes, and depreciation. If the railroad constructs its own steam power plant, a site is usually selected adjacent to its own tracks to facilitate delivery of coal, at some point where it can obtain a suitable supply of water for condensing and boiler feed, and as near as possible to its center of load. The railroad may in many cases have some advantage over the utility in cost of fuel per ton. On the other hand, the utility, with its larger and diversified load, would use generating units of larger size and better economy. The railroad should be able to obtain its capital at a somewhat lower rate of interest, and usually would carry somewhat less of a tax burden on its power-plant property. Depreciation account should not be materially different in either case. A power contract, if negotiated, should be on terms which will be advantageous to both parties to the contract. Under conditions of equal cost, the railroad will prefer to purchase its power rather than tie up a very considerable amount of capital in a power plant.

SAVINGS IN FUEL

Under present average conditions, the weight of fuel consumed in a steam locomotive per 1000 gross ton-miles will probably range from three to four times that of the fuel consumption in a large power plant of high economy for the supply of energy for equal performance by an electric locomotive. Actual consumption of locomotive fuel or electric energy per 1000 gross ton-miles over any specific route will depend on profile, alignment, speed, and a number of other factors. In localities where locomotive fuel may be obtained at relatively low cost, the net saving in cost of electric energy whether purchased or produced, whichever may be the cheaper, as compared with cost of fuel for the steam locomotive, may be expected to be rather small. In fact, if comparison is made with steam locomotives of the highest fuel economy now attainable it may be about an even break. On the other hand, in localities where locomotive fuel is relatively expensive, the cost of electric energy should normally be increased only by the amount of the corresponding increase in its power-plant fuel item, all other items such as plant labor, capital charges, etc., being not affected. This would indicate that in such localities there should be a very substantial net saving in cost of electric energy as compared with that of locomotive fuel.

In drawing a comparison between cost of locomotive fuel and cost of electric energy for equivalent work performed, it should be borne in mind that almost invariably higher average speeds are established for electric operation than were obtained with steam operation. For long runs, as in main-line passenger and freight service, this means higher average train resistances, and for short runs, as in suburban commuter service, it means both higher train resistance and more energy dissipated in brakes. The price of increased speed is higher energy consumption, and a part of its cost should be charged off to the advantage derived from the improved schedules. In the case of surburban multiple-unit service, the rates of acceleration obtained usually range from $^3/_4$ to $1^1/_2$ m.p.h. per sec. Such rates of acceleration are entirely impractical with locomotive operation, since they would require tractive efforts greater than the limit of adhesion of drive wheels.

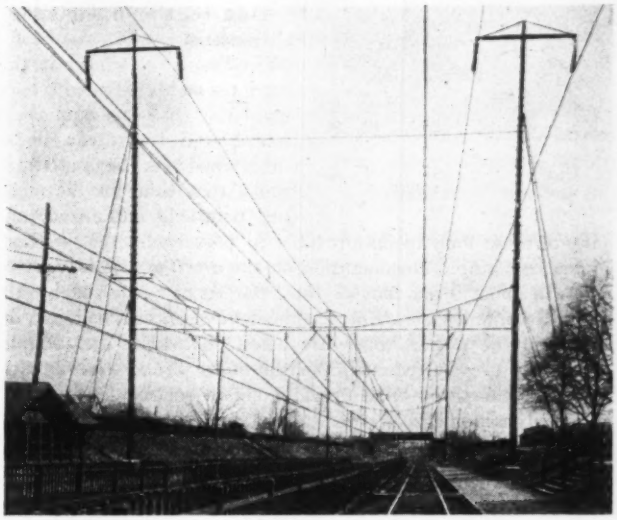
CREW WAGES

The direct savings obtainable in wages of train crews constitute an item of considerable importance, particularly in freight operation, where train weights can be increased and total time over the run can be reduced. In certain instances where comparison figures have been obtained for divisional freight service, the cost of this item, after electrification, has been cut nearly in half. In main-line passenger service, using electric locomotives, the savings obtainable in crew wages will be small, due to the fact that crew wages in passenger service are for the most part determined on a straight mileage basis. In suburban multiple-unit passenger service, the motorman takes the place of engineer and fireman on the steam locomotive, thereby saving the wages of one man per train.

MULTIPLE UNITS VERSUS ELECTRIC LOCOMOTIVES

The question might be raised: Would not multiple-unit service be more economical than electric locomotives in all main-line passenger service? Of course many passenger trains must be made up, in whole or in a large part, of cars which must go outside of electrified territory, and such trains must naturally be hauled by an electric locomotive which can conveniently be substituted for the steam locomotive at or near the limits of electrified territory. But confining the question to trains which do not go outside of electrified territory, and assuming a passenger service with station stops sufficiently far apart that the higher rate of acceleration possible with the multiple-unit train is a negligible factor in making the desired schedule speed, let it be also asssumed

for the sake of fairness to the locomotive side of the question, that electric locomotives of several different weights and hauling capacities are available, so that it will not be necessary to use an oversized locomotive to haul an undersized train. In a typical case analyzed, it was found, as might naturally be expected, that for trains of four or five cars, or less, the multiple-unit equipment has the best of the argument in each of the important items affected, including cost of energy, crew wages, maintenance of equipment, and capital charges on equipment. For trains of eight or ten cars, or more, the advantage goes to the electric locomotives, particularly in the items of maintenance and capital



PENNSYLVANIA RAILROAD 132,000-VOLT TRANSMISSION ON ELECTRIFICATION PHILADELPHIA TO WILMINGTON

charges on equipment. For trains of five to eight cars, the figures indicated that the honors were about even.

OTHER DIRECT SAVINGS

Other direct savings obtainable in the classification of maintenance and transportation expenses are: Engine-house expense, water for steam locomotives, lubricants, and other supplies for locomotives. These items are relatively small compared with the items of locomotive repairs, fuel, and train-crew wages, already discussed, but in the aggregate the obtainable savings should not be overlooked.

MISCELLANEOUS AND INDIRECT SAVINGS

There are a number of other important items of savings and advantages obtainable by electrification, some of which may be very difficult to evaluate. In many projects the total net direct savings due to electrification may be insufficient to show a satisfactory return on the new capital required. In such cases, these indirect and collateral savings and advantages are often the deciding factors in the adoption of a program of electrification. Some of the more important of these factors are the following:

1 Increasing the traffic capacity of congested trackage and enabling the construction of additional main tracks or other very expensive betterments to be deferred. This result may be attained by increasing the speed and weight of trains, particularly in freight service over a broken profile, with greater punctuality under all weather conditions.

2 Reduction in cost of maintenance of track, by reason of the elimination of cinders, requiring less frequent cleaning of rock ballast, and ability to maintain better drainage.

3 Reduction of damage claims in delivery of perishables, by reason of greater punctuality of arrivals.

4 Release of equipment used for the transportation of locomotive fuel, and making such equipment available for revenue freight.

5 Reduced outlay for rolling equipment, both passenger and freight, due to increase of schedule speed.

6 Reduction in cost of maintenance of bridges and other structures, by elimination of stack blast.

7 The elimination of smoke in tunnels and terminals, which in some cases is a determining factor in the design of terminal improvements.

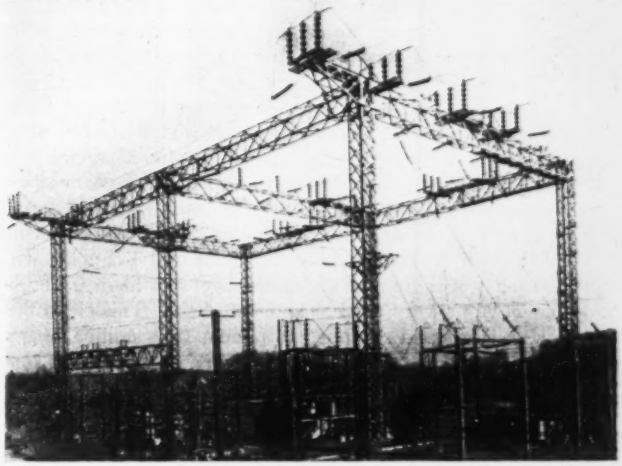
8 Increased revenue from growth of passenger traffic, stimulated by the greater attractiveness of electric operation. This is especially true of suburban passenger service.

ELECTRIFICATION WORK NOW UNDER CONSTRUCTION

The Delaware, Lackawanna and Western Railroad is now engaged in the electrification of its suburban service from Hoboken to Dover, with branches to Montclair and to Gladstone—a total of about 73 route miles, and 150 miles of track. This electrification will be the first in this country to use multiple-unit car equipment on 3000 volts d.c.

Its program calls for beginning operation in the summer or fall of this year.

The Reading Company has under construction the electrification of certain of its suburban services out of Philadelphia, embracing about 50 miles of route and 110 miles of track. An interesting sidelight on this suburban electrification is that one of the branches now being electrified comprises a short stretch of single-track line on which the major portion of the steam service formerly operated has been temporarily replaced by motor-coach operation.

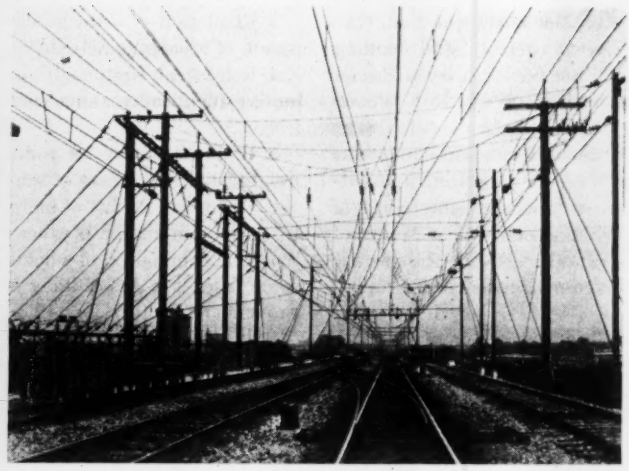


LENNI SUBSTATION OF WEST CHESTER ELECTRIFICATION

The Pennsylvania Railroad now has under construction the extension of its electrification of its suburban service from Philadelphia to Norristown, and Philadelphia to Trenton. Work is also in progress along its four-track main line between Trenton and New York, on the completion of which the electric operation of through passenger and freight service will be inaugurated from New York to Philadelphia and Wilmington. It is expected that this main-line electrification will later be extended from Wilmington to Baltimore and Washington.

The New York Central is extending its electrification for freight service south from Spuyten Duyvil, along the west side of Man-

hattan Island. It is understood that the southerly end of this zone will be operated, in part at least, by so-called "three-power" locomotives, which have been developed to derive their power either from a third rail or from an oil-electric-storage battery combination, or from the storage battery alone, with oil engine shut down, when working inside of warehouses or piers, where the exhaust from the oil engine would be objectionable.



SUBSTATION TIE-IN ON BAY RIDGE ELECTRIFICATION OF LONG ISLAND AND NEW YORK CONNECTING RAILROADS

PERFORMANCE OF EXISTING STEAM-RAILWAY ELECTRIFICATIONS

The performance of electric locomotives on the eleven more important railway electrifications in the United States for the year 1928, measured in locomotive-miles prorated to 100 tons on the drivers, amounted to a total of nearly 23 millions. More than one-half of this total was performed by two roads, the St. Paul and the New Haven. The St. Paul leads in the number of miles of route and of track electrification, but the New Haven is far ahead in amount of traffic moved.

Illustrative of the long life of the electric locomotives, when measured in miles of service, 41 passenger locomotives of the earlier type recently completed their first 20 years of service on the New Haven Railroad with a total mileage per locomotive of about $1^1/_4$ million miles. These locomotives still handle important fast trains—a record never equaled in steam service. As for freight locomotives, some 36 locomotives in 15 years of service have run up a total of nearly $^1/_2$ million miles per locomotive.

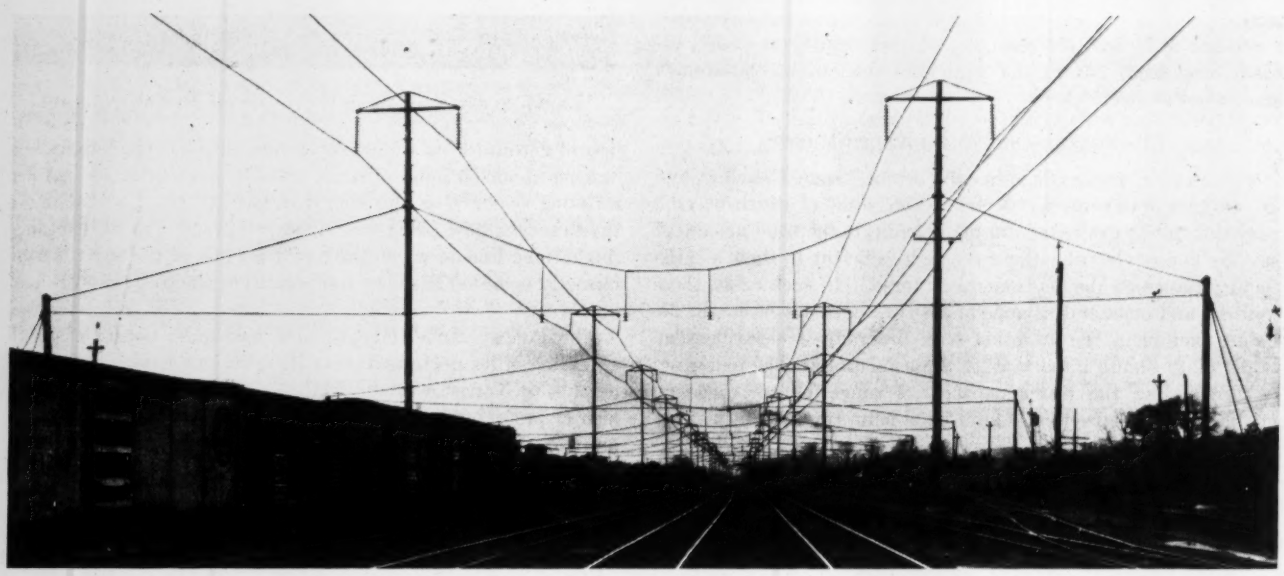
In the field of heavy-tonnage operation, the electrification of the Virginian Railway between Mullens and Roanoke, with some 134 miles of route over the summits of two main mountain ranges, is giving a very good account of itself. This electrification was designed and equipped to handle $12^1/_2$ million tons of coal per year, and has already set the mark at 11 million tons, with indications that present facilities will be adequate for traffic up to 15 million tons per year.

East-bound trains of 9000 tons complete their runs over the electric zone at schedule speeds well in excess of $12^1/_2$ miles per hour, so that it is quite exceptional for crews to make overtime rates on these runs.

Due to the fixed speed characteristics of the split-phase locomotives used on this road, the trains move with such regularity that east-bound and west-bound trains can be so dispatched over the single-track route that time lost at meeting points is minimized, and many of these long trains are able to pass each other without coming to a stop. Regeneration on the down grades is reported to return about 9 per cent of the total energy received by the locomotives, and by careful arrangement of train schedules, demands on the power house are eased. Drawbar and coupler failures are greatly reduced, and the life of brake shoes greatly increased, compared with previous steam service. A test run with a dynamometer showed a sustained drawbar push with a 9000-ton train regenerating down a heavy grade east of Merrimac of 210,000 lb. at a speed of 14 m.p.h., which is equivalent to absorbing nearly 8000 hp.

CONCLUSION

So far as the author is aware, all of the existing steam-railway electrifications in the United States have met all the requirements for which they were originally designed and constructed and have adequately justified their construction by results which could not economically have been secured by any other means. A majority of these have now given 10 or more years of service, a period long enough to develop and correct any minor defects.



CROSS CATENARY BRIDGE IN THURLOW YARD, WILMINGTON ELECTRIFICATION

The Work and Influence of the Engineer

By RALPH E. FLANDERS,[1] SPRINGFIELD, VT.

WE HAVE been looking forward for many months to this fiftieth anniversary of our Society. It has appealed to the imagination in many ways. In the first place, it is a family affair of our members, in the course of which we gather to review the past, rejoice in the present, and pledge our mutual cooperation for the future.

Beyond this, we have looked forward with eagerness to the privilege of meeting and making ourselves acquainted with our friends of sister professions and from sister nations. We had hoped for, and have not failed of, a human intercourse of a most satisfying and valuable sort.

Above all, it had seemed to us that we might attain in this intercourse to something of still higher worth. We are blessed here in Washington this week, and particularly in this room tonight, with an assemblage of acknowledged leaders in the engineering fraternity, honored alike by their own national societies and by world-wide professional recognition. Such, gentlemen, you are; and being such, your presence here tonight offers a unique opportunity for us to talk over, in an informal way, some of the problems which affect the welfare of human beings in our times —problems for which engineers have a responsibility, and for whose solution they should hold the keys.

In this country there has been a recent, widespread, and deep interest in the engineer. For a hundred years, in our applications of pure science and in our contributions to the practical sciences, we have been the active agent in the transformation of society. The pure scientist and the unscientific inventor have long been in the public eye. Only in the past year or so, owing perhaps to the elevation of Mr. Hoover to the Presidency, has our profession come into the floodlight of public interest.

Magnificent Productivity—Engineering's Priceless Gift to Humanity

In newspapers and magazine articles and in books the engineer is being described and analyzed, his work evaluated, and his possibilities predicted. At this moment in America he is the center of attraction in the minds of thoughtful people. The criticism is for the most part friendly. There is a general feeling that he should be allowed a wider range of influence in the social organization—and the hopes based upon his past record and present performance are uncomfortably high. It is this general subject of the engineer in his social relations and possibilities that I am privileged, by the grace of my associates, to discuss with you tonight.

Engineering, and industry based upon it, have bestowed at least one unquestioned and priceless gift on humanity. This is the gift of magnificent productivity.

In simpler days, not many centuries back in time nor many thousand miles away in space, the individual man, assisted by his family group, by continuous and concentrated toil could do little more in the twelve months than provide the bare necessities of food, clothing, and shelter. Broadly speaking, if *A* was rich, it was at the expense of *B* and *C* and *D*, who were each pushed a step nearer to impoverishment by the demands of *A*. The raising of a lordly building or the defense of the realm from external violence directly and indirectly impoverished its thousands. Accumulation at one point meant beggary at another.

When in the due process of history the engineer arrived, his work quite changed the scheme of things. By scientific design, construction, and management of the implements of production and distribution, he increased the productivity of the individual man ten-, fifty-, and sometimes a hundredfold. Of that hundredfold he may, if fortunate, get sevenfold for himself. *A*, the skilful accumulator of wealth, may get ninetyfold, but *B*, *C*, or *D* at least get threefold. There may be no equity discernible in the distribution. But the engineer's efforts have resulted in harm to no one, at least some slight benefit to every one, and the possibility—for the first time—of plenty for all.

The provision of an adequate surplus of food, clothes, the materials of shelter, and innumerable other material goods is the unquestioned achievement of the engineer.

With proper distribution—not yet attained—this surplus is capable of yielding desirable things, or fruitful leisure, or some of both, to every member of a properly balanced industrial society.

To the extent that this surplus is wisely distributed—and every year sees an advance in this respect—human relations take on a new and more friendly aspect. When it is seen that engineering skill and cooperative effort are more effective in the accumulation of wealth than are robbery and social disorganization, under whatever legal mask they may be concealed, then is the world ready for that "new kindliness" which Dean Kimball assures us is already in evidence in American industrial life.

To the pure moralist, this "new kindliness" based on improvement in material things may seem to be non-moral or unmoral, being arrived at too easily; but, as we are assured by that brilliant English clergyman, Dean Inge, there are many arrangements of the Deity which perplex the man who is a moralist and nothing more.

The engineer, then, has provided the surplus, and with it the partly realized possibilities of general plenty and leisure, with a corresponding improvement in the relations of man to man. He has, in addition, certain qualities to contribute.

One of them is hard-headedness. He is not accustomed to flying off on unproved theories. Everything he touches his hand to is required to work. His failures are few, and, for the most part, unimportant. There is a certain definiteness about his methods which is sadly lacking, for instance, in those new sciences, sociology and psychology. For these sciences wide but unsupported claims have been made which have aroused vain hopes in our minds in times past. The engineer, even though his field is narrow, is a far safer guide on the road of social progress.

The engineer, finally, is quality-minded, without losing the benefits of his special forte of quantity production. The product of which has had prolonged and intense engineering attention is almost sure to be a quality product. This is noticeably true

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Address delivered at the 50th Anniversary Celebration of The American Society of Mechanical Engineers, Washington, D. C., April 7, 1930.

of those which have been subjected to engineering standardization. Such standardization is a grading upward, not downward; and its prospective extension into the equipment and materials of the ordinary household will be an unalloyed blessing.

The Engineer and the Attainment of Enduring Satisfactions

The problem before us is to determine how best to apply these material goods and personal qualities of the engineer to the problem of social progress. Pardon is asked for the very condensed and rapid survey which is required by the shortness of our time and the breadth of the subject.

The object of our inquiry is the attainment by the average inhabitant of the modern civilized state of what we may call the "Good Life." I am going without further apology to attempt a definition of that somewhat debatable term.

The Good Life in general is one characterized by enduring satisfactions rather than by transient and changing flashes of pleasure.

One of its prime elements is functional satisfaction—the deep sense of well-being which fills us as we successfully exercise the organs, the instincts, the faculties—inborn and acquired—and the store of experience which all combine to make up the individual personality.

This functional satisfaction may be drawn from the daily work—from the trade or the profession, the research of the scientist, or the managerial efficiency of the industrial leader.

Functional satisfaction can be found in hobbies as well; likewise in recreation—gardening, playing bridge, or sailing a boat. Anything which permits the acquirement and exercise of skill will serve. In many people this outside interest is so strongly developed that they are content with a monotonous and uninspiring occupation if it gives them the needed money and leisure for their real interests.

The consciousness of enlargement of the personality is another element of the Good Life. In a sense it is the dynamic form of the more static functional satisfaction. The increased acquaintanceship with books, travel, the widening of acquaintance, the elaboration and deepening of all contacts with life, serve this elementary need.

Most of us cannot do without some measure of objective achievement. To see the hidden idea, the faculty, the personal growth expressed in material form, is to intensify their value to us. The slowly built and lovingly tended garden, the finished technical paper, the selected and cultivated group of friends, the close-knit business organization, the adopted social policy—all these concrete embodiments of immaterial forces put the crowning touch on days of patient concentration.

This element is weakened under modern conditions for the ordinary worker by the rarity of his contact with the finished work to which he is contributing. Special provision for this contact would greatly increase his satisfaction.

Social integration is a deep-seated human need. Family love, love between the sexes, friendship, the bonds of social, professional, and political organization—all those ties by which one lends his strength to many, and the many support the one, are necessary to the fully rounded life.

Last in the ascending series and most difficult of attainment is the sense of cosmic integration—the assurance of a place in an ordered universe.

To provide this place is the function of religion and philosophy. It was the difficulty of retaining this deepest and most serene of the satisfactions in the face of the accumulated knowledge of the centuries from the 15th to the 19th, that accounts for the spiritual hunger of the last generation. The sudden expansion of physical knowledge in our new century—sudden to the point of explosion—is happily bearing fruit in a clearer cosmic viewpoint. I shall refer to this later.

Among the durable satisfactions I have not mentioned is that of recognition—the appreciation and approbation of our fellows. This may be very solid and real, but only if it is not consciously sought for. Those of us who have critically considered our lives for any extended time will assign a doubtful value to this desire for recognition. If it comes unexpectedly and unsought, well and good. But for the most part it is a devouring appetite rather than a durable satisfaction.

All the good things outlined above, in their varying degrees and kinds, may be enjoyed by all sorts and conditions of men in their appropriate ways.

Concrete Material Factors Whose Provision Lies Within the Province of the Engineer

Let us next proceed to consider some concrete material factors whose provision lies within the province of the engineer, which will minister to the durable satisfactions. Let it be understood that in the brevity of our discussion the connection will not always be made explicit. And let it be further understood that society cannot guarantee the satisfaction of the individual. It can only provide him with favorable conditions.

One condition that engineering progress provides has already been mentioned—leisure and material plenty for all are now physically possible. That this possibility is not an actuality is due to social maladjustments which must be remedied—in part by further social and economic research and in part by the self-imposed discipline of the individual. Of this also more later.

As an allied factor, stability of employment is a possibility. No engineer would be satisfied with a "hunting governor" on a 100,000-kw. steam turbine and generator tied into a widely ramifying super-power circuit. Yet the term "hunting governor" does not begin to describe the faults of that much-praised regulator of industry and commerce, the speculative stock market. Our clumsy financial governor demands research and redesign from the engineering viewpoint; but a rational control of the speculative impulse in the individual is necessary also—and experience is teaching this hard lesson.

Besides the steadiness of operation which assures steadiness of employment, the mass of the population should find some relief from the deadening fear of sickness and old age for which no financial provision can be made. Sickness may be partly avoided by that admirable development of preventive medicine which so closely parallels the work of the engineer. But some degree of sickness will always be with us, and none can escape old age save by premature death.

Many of you have read "Middletown," that detailed, monotonous, occasionally interesting, usually drab, but always significant survey of a medium-sized industrial city in our Middle West. If you have read "Middletown," you will not soon escape from the impression of impending disaster always hanging over the working population from the triple menace of unemployment, sickness, and old age. The antidote for that menace lies in the surplus which engineering stands ready to provide. And that surplus can always be increased when we are ready to abandon wasteful competition, extravagant salesmanship, and inefficient management. But we have not yet solved the problem of applying the surplus to afford the required relief in a socially desirable way.

As a specific picture of general improvement (one only of many possible ones), imagine the dirty, crowded, flimsy quarters of Middletown's working population destroyed. In their place build a network of cement highways radiating into the surrounding country, and sprinkle along it desirable houses or groups of houses set in garden plots of one-half to five acres. All homes

would have their vegetable gardens. Many would have poultry. Some few would have a cow or two. An amphibious society like this, living partly in industry and partly on the land, would have greater stability and be within closer reach of the enduring values than is now possible to them. Better equipment and management can shorten the working hours to permit the day or two of farm work per week. And engineering builds the concrete roads, the autos, the school buses, the telephones, and the radios which destory the demon of isolation.

It would be folly to attempt to design a completely safe and automatic social mechanism. We would not if we could. It would destroy important human satisfactions to relieve man of all his responsibilities. Such safety would be purchased at too high a price. To a great degree each man wants to be the architect of his own fortunes.

Nor would we destroy the privilege of offering and accepting neighborly kindness. When this is no longer necessary, something worth while will have gone out of life. It would do violence to the value of social integration. When there is no substratum of social injustice to sour the soul, these friendly offices can be received as freely and gladly as they are offered.

Life, on the whole, has been easy for us here in America. We are not more virtuous or more intelligent than the other races of the earth. But we have had a continental area to develop—rich in almost every raw material required by modern industry; and our isolation has permitted us to concentrate habitually on peaceful activities. These conditions have produced an unparalleled expansion of wealth which has descended, however scantily, further down the social scale than in any other place or period recorded in history.

EVENTUAL SLOWING UP OF THE INDUSTRIAL TEMPO INEVITABLE

The mechanism of this prosperity has one weak link. It has been geared to a constantly increasing tempo of production, based in turn on increasing population, increasing development of natural resources, and an apparently limitless proliferation of science and invention. We have been prosperous during periods of rapid growth. Not stoppage, but a mere slowing in the rate of expansion has been enough to derange the mechanism of production, distribution, and finance. The machinery was not designed for a flow at a continuous rate, and cannot be so used, apparently, without radical changes.

This is a real weakness, for it seems sure that an increasing rate of expansion cannot be a permanent condition. By birth control and restriction of immigration we are keeping the growth of population within limits. We have already seen the advisability of replacing exploitation of resources by conservation, and are beginning to practice it. What about the continued proliferation of invention? The bicycle, the motor car, the tractor, motorized household equipment, the radio, the airplane—then what?—and then what?—and then what?

It is true that there have been many false alarms of a slowup in material progress. As early as the closing decade of the seventeenth century, Charles Perrault of France wrote:

> Our age has in some sort arrived at the summit of perfection. And since for some years the rate of progress is much slower and appears almost insensible—as the days seem to cease lengthening when the solstice is near—it is pleasant to think that probably there are not many things for which we need envy the future generations.

This seems amusing and incredible. But I am told that a director of our own patent office, some time in the 1850's, resigned his position because it had no future. All the possible inventions of importance had already been made.

But listen to our own Dr. Millikan, writing in *Scribner's Magazine* for February of this year:

> It is difficult to see how the future can have any other period of such rapid change in store.
>
> In the way he conducted his daily life my grandfather is indubitably more remote from me than he was from the earliest man mentioned in recorded history. . . . . In many fields no past time has known and no future time can know so sudden and so complete a transformation.

What shall we say to all this, when prophecy has so often been disconcerted by the facts? We can only say that some time, when we know not, the prophecy will come true—at least for a time.

There are rhythms in Nature—systole and diastole of the heart—inhalation and exhalation of the breath—high tide and low—day and night—summer and winter—and the larger rhythms of the glacial periods and the geologic eons. Shall not our scientific and engineering efflorescence have its period also?

We might well pray for a change. In our industrial development we have been as though living in the mad rush of a pioneer period. Year by year we have crossed the rivers and the ranges, hastily scratched the soil with our plows, raised our scanty crops, and moved on. The time has come to occupy the land, to subject it to high cultivation, to plant the vine and the fig tree, and to build stately mansions.

TIME RIPE FOR APPLICATION OF THE ENGINEERING VIEWPOINT TO THE SOCIAL MACHINE

There will be no definite, clear-cut line of division ending the pioneer period and inaugurating that of occupation and development. New territory, large and small, will be opened up from time to time. But there is much reason to believe that we have already come to the turning point in industry and invention, and that from now on the men of keenest intelligence and widest experience will find that the work worthy of their abilities lies in the neglected field of social organization and control.

The time has come, then, to apply the engineering viewpoint to the social machine—to improve its efficiency, its durability, and the excellence of its product. In urging this we are not uttering solitary cries in the wilderness or speaking into deaf ears. The way is being made ready.

There is, for example, that new interest in the engineer and his way of working, already mentioned. The idea that his methods can be socially applied has caught the popular imagination.

Then there is that idea of "service," much ridiculed, but conveying a basic truth. In the primitive "starvation economy," described earlier, when *A* bargained with *B*, the margin of profit was small, and one of the two was almost certainly a loser. Under modern "surplus economy," as derived from the work of the engineer, the normal business transaction results in unquestioned advantage to both parties. There may be jockeying over a division of the profits, but some part will go to each. This simple fact has completely changed the atmosphere of modern business. It is full of the oxygen of mutual confidence and respect. It furnishes ready-made the ideal background for the coming change. The "new kindliness" is one of its overt manifestations.

Another of the straws in the wind is the progressive refinement in the practice of philanthropy. The stages are clearly visible. Fifty years ago a wealthy man would provide in his will for a public drinking fountain and horse trough in the town square, adorned with a marble statue of himself, mutton-chop whiskers, congress boots, and all. The next ascending stage was the endowment of a self-named institution—library, hospital, or college. Next came the occasional case of the anonymous donor, often of large gifts; and, paralleling that, the instituting of foundations for social purposes in which the money gift is only one element, the balance being the careful and yet bold exercise of organizing ability and business direction—gifts of greater value than those measured in dollars.

And last in the series there is that still rare but occasional philanthropist who expresses himself in an integral, organic benevolence. The principal concern of such a man is to so order his affairs that "the very earning of his money is itself a social service, irrespective of the use he later makes of it. So far as our present vision goes, the biggest social service the individual can render is to engage in the manufacture and distribution of goods which are useful, or beautiful, or both; and so to do this as to give secure, remunerative employment to the largest possible number of people, under working conditions which give full opportunity to ability and satisfy the requirements of human dignity and self-respect."

The Attainment of Cosmic Integration

The important elements in this new viewpoint of industrial life are, indeed, only a generation old.

That last and deepest value—cosmic integration—has waited on the work of such men as Einstein, Eddington, and Millikan. The farthest and deepest reaches of mathematics, physics, and galactic astronomy were necessary for its formation.

It is being seen and described and analyzed by such men as Professor Whitehead, whom Harvard has borrowed from Cambridge University to fill her chair of philosophy.

After pages of metaphysics as modern as the radio but as deep as the universe, in the midst of which he flows over and around and past such minor problems as the freedom of the human will and the difficulties of the relationships of mind and matter—floating these things off as light and empty wreckage on the full tide of his argument—after pages and chapters of subtle reasoning, he delivers himself of paragraphs like these:

> The watchwords of the nineteenth century have been struggle for existence, competition, class warfare, commercial antagonism between nations, military warfare. The struggle for existence has been construed into the gospel of hate. The full conclusion to be drawn from a philosophy of evolution is fortunately of a more balanced character. Successful organisms modify their environment. Those organisms are successful which modify their environments so as to assist each other.
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> The point is that professionalism has now been mated with progress. The world is now faced with a self-evolving system which it cannot stop. There are danger and advantages in this situation. It is obvious that the gain in material power affords opportunity for social betterment. If mankind can rise to the occasion, there lies in front a golden age of beneficient creativeness. But material power in itself is ethically neutral. It can equally well work in the wrong direction. The problem is not how to produce great men, but how to produce great societies.
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> But, in this sense, art concerns more than sunsets. A factory with its machinery, its community of operatives, its social service to the general population, its dependence upon organizing and designing genius, its potentialities as a source of wealth to the holders of its stock, is an organism exhibiting a variety of vivid values. What we want to train is the habit of apprehending such an organism in its completeness.

Unless one has undergone the discipline of philosophy in the schools, the basic metaphysics is only dimly understood. But these disconnected paragraphs, inadequate though they seem apart from their context, are scattered fragments from the message of a prophet who is already walking ahead of us into the new age, pointing out the way and reporting on the grandeur and beauty of its aspects. That new age is one of human rather than material development.

We have reached indeed a fortunate and thrilling moment in the flow of history. One civilization after another has been born, grown, matured, and met defeat at this crisis we now face. In past times, whenever the automatic, naturally evolved safeguards of traditional religion and old customs have dissolved under the spell of increasing critical judgment, so that men have had to govern their social relations directly by their own intelligence and good-will, hitherto they have always failed.

Now we come to the same narrow pass, but with clearer guidance. Thanks to the scientist and the engineer, we have adapted ourselves to natural laws, and for the first time control our material conditions. We are blessed also with the historical sense, which puts our own cycle into its place in the long perspective and warns us that the zero hour approaches. We live in the kindlier human atmosphere, born of the new economy of the surplus. And lastly, with generations of a religion of good will behind us, we are armed with that mighty and indispensable weapon for the conflict that is ahead.

We face one of the greatest events in human history—and we will not fail.

Mechanized Civilization

A COMMON indictment against modern conditions is that machine tending is "soul-destroying." It is, of course, undoubtedly true that such work is highly repellent to many, but it is equally true that there are large sections of the population who welcome it, and rejoice in the greater leisure gained and the good pay earned.

The critics also assert that the machine treats labor as a quantity—"so many hands, so many hours, and so many hand-hours." As a matter of fact, however, it was Dr. F. W. Taylor, the pioneer in modern methods of mass production, who insisted that labor was not all alike, and could not, therefore, be treated merely from the quantitative standpoint. He maintained that none but first-class men should be employed, but observed that he had yet to find a healthy man who was not first-class at something. The truth is that, in this so-called mechanized civilization, man as man counts for more than in any other period of the world's history. . . . The engineer feels that it is degrading labor to set it at tasks which can be better done by a machine.

Somewhat similar considerations apply also to the charge that the engineer is callous of beauty. His work is as yet in its infancy, and until recently his problem has been to make his conceptions work, and the difficulties have been such as to preclude as much attention to esthetic considerations as might be wished, and which the growing popularity of the machine will make possible in the future. Even as matters stand there is even in esthetics a balance to the credit of the engineer and man of science. The beauty of life exceeds that of stone, and the better health of the civilized communities of today must undoubtedly have implied a very distinct gain in this respect as compared with those of the past, in which smallpox and often leprosy were endemic.

To sum up, whatever the defects of modern conditions, and no one is more fully alive to them than the engineer, it is on the engineer that will mainly fall the work of removing them. Such abuses as there have been of the powers he has shown how to control, have been mainly due to the politician and the economist, both of whom have in the past shown themselves very reluctant to seek his advice and assistance in matters of policy.—From *Engineering*, July 25, 1930.

"Carrying the Load"

An Outline of the Problems Encountered and the Steps That Have to Be Taken to Insure an Adequate Present and Future Reliable and Continuous Supply of Electricity in a Metropolitan District

By ALEX D. BAILEY,[1] CHICAGO, ILL.

FORMERLY, when "carrying the load" was mentioned, the usual conception was that of a dark and stormy night, cold and miserable, with power houses dirty and dismal and everything going full blast; the men in the boiler room working feverishly to keep up the steam pressure, and those in the engine room watching their equipment, with dubious head shakings and doubts about its ability to stand up under the strain; a high nervous tension, and then a glorious feeling of relief when the peak was past for another day. Service had been maintained and the equipment after undergoing examinations and minor repairs during the night, and throughout the following day, would be ready for the next day's performance. Saturday nights, Sundays, and holidays were the only times when machinery could be spared from service for extensive repairs, and these week ends were nightmares of drudgery, sweat, and profanity.

Today, however, things are entirely different, as improvements in equipment and in the organization of electric utility companies have pushed the old picture into the background. The responsibility of those in charge, however, has increased immeasurably, and customers are demanding a quality of service previously undreamed of.

Service

At the present time, the word "service" is probably employed more than any other to express a quality of performance for which no other vocable suffices. It is difficult to say just what "service" means, yet we all understand what is intended when we hear the word. We generally consider that it means a reliable and continuous supply of electricity at a reasonable rate, but the conditions vary with localities. Richard T. Higgins, chairman of the Public Utilities Commission of Connecticut, stated in a recent speech: "The community has a right to expect adequate service at reasonable rates; the degree of adequate service and reasonable rates depending upon the immediate or local conditions, as adequate service and reasonable rates for a rural or thinly populated community might be wholly inadequate and unreasonable for a populous district." This, it seems, states the case quite fairly. It is evident, then, that in a metropolitan district, such as that surrounding and including any large city, the customers are entitled to the highest quality of service at a minimum cost.

Continuity of Service

While it is true that operating men have been drilled and impressed with the importance of "continuity of service," that is, uniform voltage and frequency on all of the buses all of the time, and while they appreciate that the slogan of the industry is "the best possible service at the lowest possible cost," we must go back of the operating organization to assure some of the requisites and fundamentals necessary for the accomplishment of this ideal. The job of the operating group is to produce energy at the minimum cost, bearing in mind the safety and protection of the system, since the "service" rendered measures the usefulness of the utility to the community it serves.

Good Design and Construction Necessary

The ability of a station and a system to generate and distribute electrical energy continuously and reliably, goes back to the design of the station and the system, and antedates the actual construction of the plant, just as the degree of economical performance is largely determined before the plant is ever built. By this it is meant that good operating results, in either particular, are impossible with a poorly designed or poorly constructed plant. The fundamentals of good plant design and construction must be followed if the installation is to function reliably and economically. The operating force must then use proper discretion, foresight, and technical care in order to get the most out of the installation.

Investment and Operating Expense

The investment in generating stations is one of the largest items in any company's investment, varying between one-third and one-half of the total. It is necessary, therefore, to utilize this investment as economically as possible and at as low a unit cost as is consistent with the quality of the service to be rendered. Station operating expense is also an important item in any company's general expense, the fuel bill being probably the largest single item. To be too economical in the investment cost may result in inferior equipment and a want of efficiency and reliability, while money needlessly spent piles up fixed charges year after year which might otherwise be avoided. There must then be maintained a very fine balance between investment and operating costs, so that the sum of the two will be the lowest possible cost consistent with the service to be rendered. It is evident that the performance of the station is largely determined before it is built, and the measure of success will be the economic balance of the various points previously cited.

Stations Are Expensive

At the present time we talk of stations with ultimate capacities of 1,000,000 kw., but we do not fully appreciate the fact that the investment in such an installation would be over $100,000,000, and that the fixed charges would be in proportion.

[1] Superintendent of Generating Stations, Commonwealth Edison Company. Mem. A.S.M.E. Mr. Bailey was graduated from Lewis Institute in 1903 with the degree of M.E. and in that same year entered the employ of his present concern where he has served in the engineering department drafting room, and as assistant chief engineer, station operation. He is a member of the Main Research Committee of the A.S.M.E. as well as of the Power Test Code Committee on Stationary Steam-Generating Units. He is a councilor of the N.E.L.A. Prime Movers Committee and has been active in the conduct of the Mid-West Power Conferences.

Presented at a meeting of the Boston Section of the A.S.M.E., January 15, 1930.

An installation of this size cannot be classed as an experiment. It is absolutely necessary that the installation shall go into service promptly, and shall operate so that good service will be rendered and economical performance obtained from the start. Units of 100,000 kw. capacity and larger are becoming quite common, and as each such installation represents the investment of at least $10,000,000, both designers and operators must be sure of results.

Reserve Capacity

The amount of reserve capacity to be installed is another item

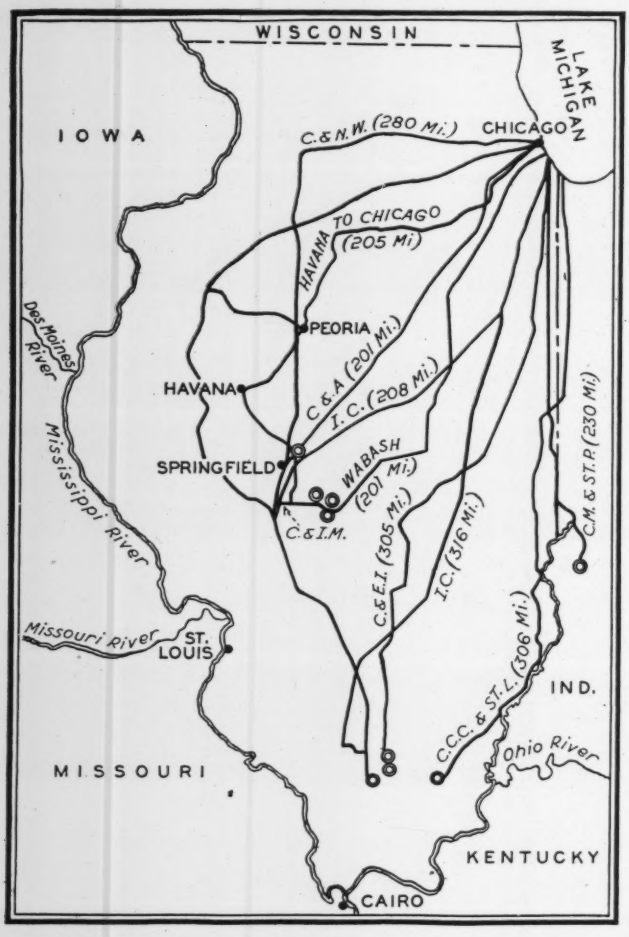

FIG. 1 LOCATION OF COMMONWEALTH EDISON COAL PROPERTIES IN CENTRAL AND SOUTHERN ILLINOIS, AND TRUNK LINES THEREFROM TO CHICAGO

which must be considered when the plant is designed, as well as the form of the efficiency curves of the main generating units. While it is the aim to obtain flat efficiency curves over wide ranges of capacity, it is generally found that the most economical point of operation is sufficiently below the maximum rating so that under normal operating conditions each unit will afford in itself a certain amount of reserve. Since we must maintain uniform frequency and uniform pressure on the buses all of the time, it is evident that the entire generating system, with its interconnections, must be carefully studied and designed so that the effect of the outage of any particular part will be nullified as much as possible.

Planning in Advance

In operating work there is always the need for exercising quick judgment, as events happen almost instantly. The only way, however, in which emergencies can be satisfactorily handled is by proper study and planning in advance. Every possible emergency must be imagined and measures to meet it determined on weeks or months before it actually happens, and arrangements must be such that each particular type of trouble will give the proper warning or signal, so that it can be quickly recognized.

Automatic Equipment

Automatic equipment is taking the place of manual operation, relieving the personnel of many operating details or exercising a protective function, but the increased use of these devices has added to the complexity of installations. There is, of course, such a thing as overdoing this automatic feature, as simplicity is essential to good operation, and we are frequently faced with the necessity for making a decision regarding a happy medium where enough automatic equipment is installed to effect better operating results or to properly protect the service and at the same time avoid that which would add complexity. Each new piece of equipment adds to the operating hazard and is a potential source of trouble. Periodically, designers and operating men wake up to the fact that installations are being overloaded with intricate devices intended for protection, but which in reality constitute an additional hazard.

Refinements in Equipment

The same argument applies to refinements and additions in order to obtain the last "whisper" in operating economy. The point is reached sooner or later where the operating gain barely exceeds the fixed charges on investment and where the operating hazard, due to complexity or potential trouble, becomes the most important factor—sometimes the deciding one.

The Chicago District

While the preceding remarks are of a general nature which will apply to almost any installation, from now on the author will deal with the particular installations with which he is best acquainted, and will attempt to present some details of a purely operating nature which may give an idea of the precautions and the general method of operation necessary to assure proper service.

Coal Supply

There is one item of investment which is so definitely connected with the operation of the Commonwealth system that it can very properly be considered an operating matter. As coal is the raw material on which we depend entirely for manufacturing our product, it is absolutely necessary, first, to have a reliable supply, and, secondly, that the cost shall be as low as possible. As a consequence, the company interested itself many years ago in coal properties in the central and southern part of Illinois which are operated under its direction; and at the point where the coal output is the greatest it has a short railroad connecting these mines with trunk-line railroads entering Chicago. Fig. 1 shows the location of these coal properties and the various trunk lines over which coal from these or any other mines can be delivered to Chicago.

Coal Storage

We are, however, a considerable distance from our source of supply and must depend upon other railroads than our own for fuel delivery, so it is very necessary for us to carry a considerable amount of coal in storage at, or sufficiently near, each of our generating stations so that it will be readily available. Each station has a yard storage capacity of from 45,000 to 160,000 tons, depending upon the size of the station, and in addition

there is a yard at Glenn, just outside of the city, of 300,000 tons capacity, from which point coal can be delivered to any of the stations. The amount of reserve ordinarily carried is between forty and sixty days' supply, but in case of impending trouble at the mines or on the railroads, or at the beginning of winter when fuel shipments are uncertain, this amount is generally increased. With this coal reserve we feel reasonably safe, as the tracks in the station yards are our own property and we operate our own locomotives for switching purposes.

POWER-SYSTEM LAYOUT OF THE CHICAGO DISTRICT

Fig. 2 shows the power-system layout of the territory surrounding Chicago, and gives the locations of generating centers as well as their interconnections. At the present time there are no increases being made in the generating capacity within the city, but considerable ones are being made at Waukegan, Powerton, and State Line, and a new plant is being built at Michigan City. Each of these will be a large generating center which will wholesale power to the connected companies. These stations are interconnected and are further connected not only with the Commonwealth Edison system and its generating plants, but with other large systems such as the American Gas & Electric to the east, and the Milwaukee Electric Railway and Light Company on the north; and power is being purchased from all three of these stations in varying amounts.

THE COMMONWEALTH EDISON COMPANY SYSTEM

About 83 per cent of the company's output is generated in its own stations located inside the city. Fig. 3 shows where these are located and also the interconnections between stations, which latter serve for transmitting power from the most economical plants to points of load density and facilitate not only the economical production of power but afford reserve for operating emergencies.

ALLOCATION OF OUTPUT

The economical operation of the system is a responsibility second only to service, and the output of the system must be divided among the various generating stations whose outputs vary from 50,000 to 7,500,000 kw-hr. daily, and whose performances vary from 30,000 B.t.u. per kw-hr. to 13,000 or less. It is necessary to operate with a loading schedule which will result in the lowest overall system production cost, and at the same time insure reliable and adequate service.

FIG. 3 PROPERTIES OF THE COMMONWEALTH EDISON COMPANY IN THE CITY OF CHICAGO

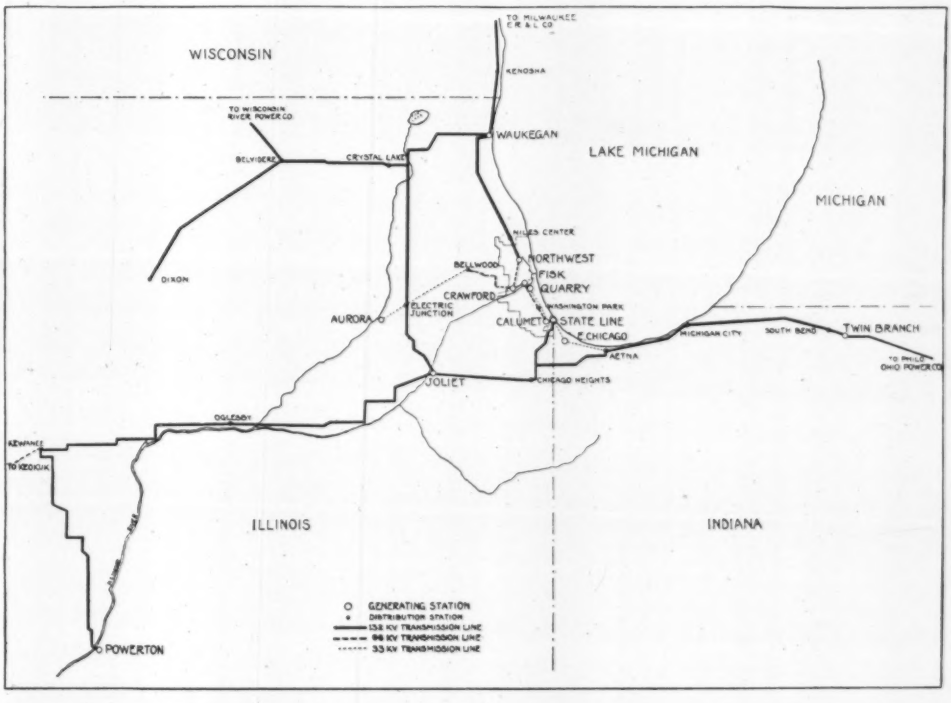

FIG. 2 POWER-SYSTEM LAYOUT OF TERRITORY SURROUNDING CHICAGO, SHOWING LOCATIONS OF GENERATING CENTERS AND THEIR INTERCONNECTIONS

LOAD SCHEDULES

As it is impossible for any man or any group to keep in touch with load conditions from minute to minute, and regulate the load which a particular station should carry; and as it would be equally impossible for any operating organization to operate economically under such haphazard loading, the loading schedule for the stations is made out in advance so that the operators in each

station will know how much load it should carry under given conditions. This schedule of load is the foundation of both reliable service and economical performance, as the correct division of the system load is based on the knowledge of each individual unit's performance over its entire capacity range, and the relation of each unit's performance to the system as a whole,

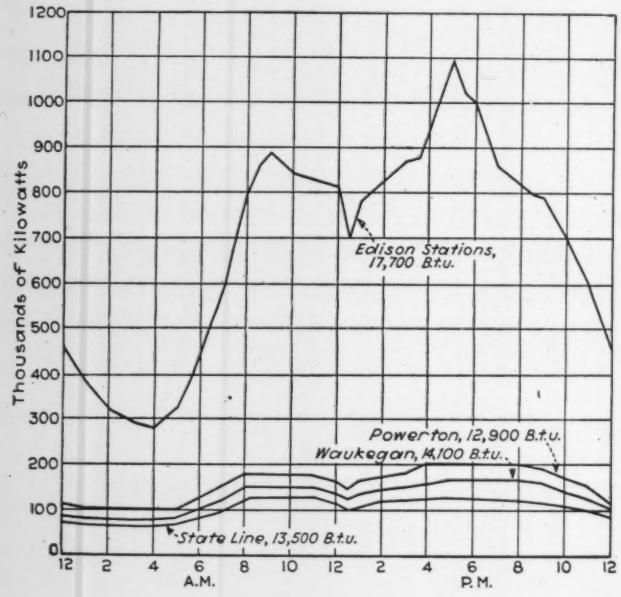

FIG. 4 EFFECT OF PURCHASED ENERGY ON SYSTEM B.T.U. RATE
(Total system, 16,800 B.t.u.)

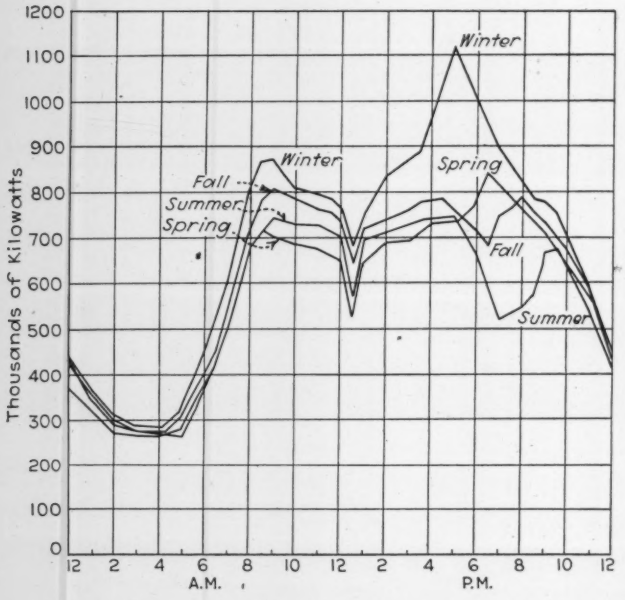

FIG. 5 SHOWING SEASONAL VARIATION OF TOTAL LOAD
(Commonwealth Edison Co., 1929.)

with due regard to reserve capacity in generating units and tie lines.

METHOD OF ALLOCATION

First of all, the output of each station is approximately determined a year in advance. In October or November an estimate of the company's output by months is made for the succeeding calendar year. The amount of energy to be purchased or to be sold and the shape of the load curves for these loads are quite accurately determined. With these deductions the monthly output of the company's own generating stations is then determined. This allocation is shown in Fig. 4 for a winter load curve.

BUDGETING

From a study of previous years, seasonal load curves are derived showing the hourly loading on week days and on Saturdays and Sundays. From these, the percentages of output on Saturdays and Sundays and on the five week days, which are generally quite similar, are determined, as well as the percentage of load at each hour of the twenty-four. Using these percentages as a basis, the next year's estimate is divided up into output for the five standard week days and Saturdays and Sundays, and from the hourly percentages, sample load curves are constructed which show not only what the load will be at any hour of the day, under normal operation, but also what the peaks will be and when they may normally be expected. Four average curves, shown in Fig. 5, are prepared, one for each season of the year, as there is a considerable variation in the amount of load between summer and winter, as well as in the shape of the load curve. By deducting the curve for purchased energy from this total-load curve, the load curve for the company's own stations is determined. From this the load curve for the most economical station is taken, giving it all the load it can economically carry

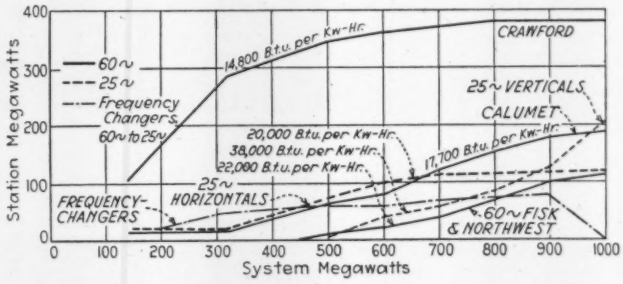

FIG. 6 LOAD-DIVISION DIAGRAM FOR TOTAL SYSTEM
(Average B.t.u. rate, 17,700.)

and keeping in mind proper operating reserve and the seasonal outage of units on account of overhauling. Following this, the load curve for the next-best station is determined, and so on down the line. From these individual load curves the station outputs are figured, and these are given to the organizations in the various stations for figuring their budget requirements. With the output and the character of the load curve given, they are able to estimate quite accurately the fuel required and the labor and maintenance expense.

THE MAKING OF LOAD SCHEDULES

With these charts as a basis, operating schedules are prepared which show the proper loading of all stations with any addition of system load. Fig. 6 shows one of these charts. As these are prepared in advance and with due deliberation and study, we are able to determine also in advance what the overall thermodynamic performance of the system will be for any given loading, and by studying the effect of load factor on any load schedule can determine the most economical manner of dividing the output.

TWENTY-FIVE AND SIXTY-CYCLE SYSTEMS

The situation is somewhat complicated by the fact that we are operating two systems, a 25- and a 60-cycle. The former, which is the older, supplies the energy for the downtown d-c. district, and the bulk of the power for the street and elevated railroads. The growth of this system has been retarded and

practically nullified by decreasing the area served and by taking increases on the other system, and as a result no generating equipment has been added to this system for about ten years. Its most efficient units, therefore, operate at about 20,000 B.t.u. per kw-hr. In order to get the benefit of the increased efficiency of the later installations, two motor-generator sets of 40,000 kw. capacity each have been installed at Fisk Street Station. These supply bulk energy to the 25-cycle system from the more efficient 60-cycle generating equipment. Of course it is always necessary to keep considerable 25-cycle capacity in service for emergencies, but this system is, in addition, fortified with storage-battery reserve, and all of this capacity on the 25-cycle system is available to help out in case of trouble on the 60-cycle system. The motor-generator sets will feed in both directions, so that either system is in a position to help the other.

In order to avoid complications, however, simple load-distribution charts are made up for each system, as shown in Fig. 7. These give the station loads to be carried for any system load. In order to make this operable, each station-control center is supplied with a recording and indicating wattmeter which shows the output of the entire system at any instant. By consulting this chart the operator can see at a glance how much load his station should be carrying at a given time, and can adjust the

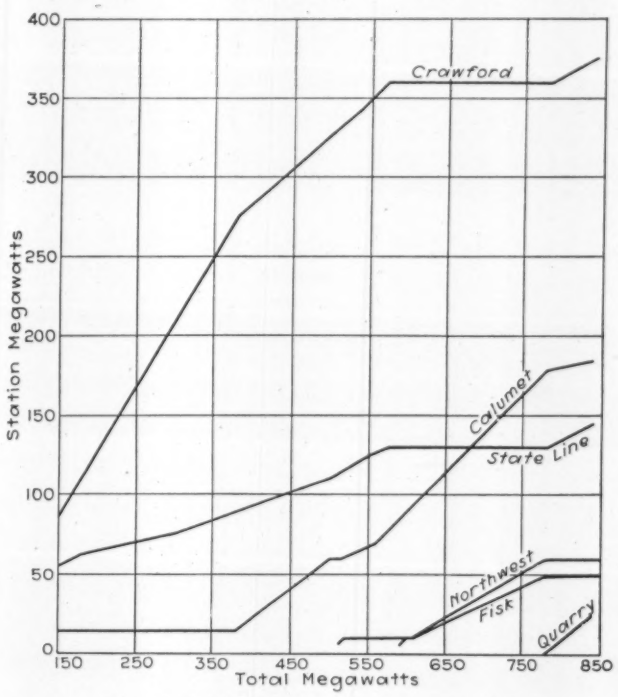

FIG. 7 60-CYCLE-LOAD-DIVISION DIAGRAM

load accordingly. This immediately does away with any attempt to steal load from other stations under favorable steam conditions or to let go of load under adverse conditions, and has a marked effect on the maintenance of uniform frequency.

At the load-dispatcher's office, which is mainly concerned with the distribution of energy, is located an additional group of recording and indicating wattmeters which show the load on each station. By comparing these with the readings of the system totalizing meter, the load dispatcher knows at all times whether or not each station is handling its share of the load. Fig. 8 shows the composite load curve for all the stations and the system. In addition it shows the loading of the motor-generator sets supplying power to the 25-cycle system from the 60-cycle. The various areas in this chart show the relative outputs of the various generating stations.

RUNNING RESERVE

While the layman might appreciate the fact that we are generating most of our output at the stations where the cost is lowest, he might jump to the conclusion that the less efficient stations could be shut down altogether. It happens, however, that we have not quite reached the stage of perfection where generating and transmitting equipment is absolutely infallible,

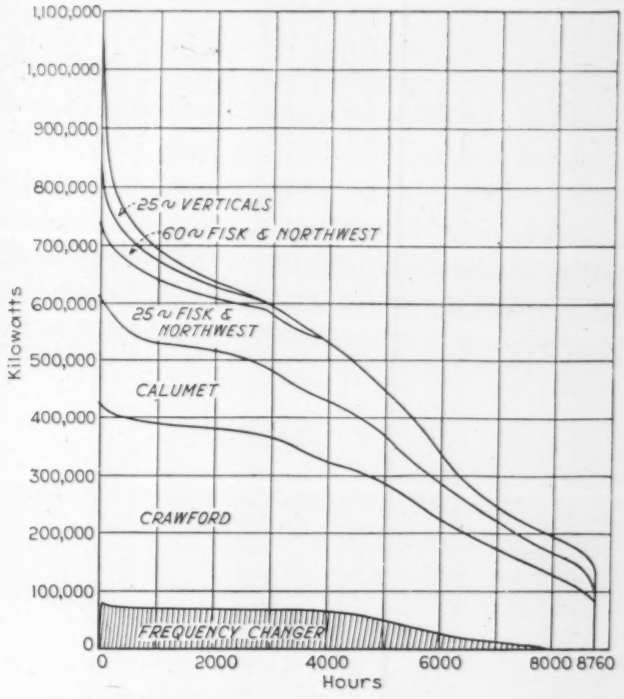

FIG. 8 COMPOSITE LOAD CURVE FOR TOTAL SYSTEM, 1928
(Load factor, 48.7 per cent.)

and since we are serving large industries and customers whose service in turn demands an uninterrupted power supply, we can take no chances. It is consequently necessary to maintain reserve at each generating center continuously and to keep this reserve in operation, as interruptions frequently occur instantly, and equipment must be in readiness to take care of such an emergency with equal rapidity. At least an hour's time is necessary to place one of the newer large units in operation, and a service interruption of that duration would be disastrous.

To guard against interruption of the service, such as low voltage or frequency, we normally maintain a running reserve equal at least to the load on the largest single generating unit. This is almost invariably greater than the load on any individual tie line or any individual piece of transformer equipment. In the case of State Line Station, where there is a capacity of 200,000 kw., of which we normally receive 120,000 kw. with a station loading of 160,000 or 170,000, or in the case of Waukegan or Powerton, where we receive lesser amounts, we depend on these stations to carry a proportional amount of running reserve which will be available in an emergency.

While of course it is advisable to carry as large a part of the running reserve as possible on the less efficient stations, it is physically impossible to pick up load quickly on lightly loaded and relatively cold equipment, and we consequently carry 10 to 15 per cent reserve on the more heavily loaded and more economical stations. This of course applies to boiler capacity as well as to generating equipment. In an emergency we are able to draw a limited amount from our connections to the east and north, or in return our reserve is available to help them out in

case of trouble on their systems. It is an interesting fact that in the case of serious generating trouble in Wisconsin some time ago, the Public Service Company operating the Waukegan station was able to assist materially in avoiding a serious shutdown by reversing the direction of flow of power between Chicago and Waukegan and drawing on our reserve as well for what it could spare to help out in the emergency.

EFFECT OF STORMS

Of course all emergencies that arise are not due to failure of equipment. Sudden storms effect increases in load which are greater in amount than those due to troubles with the equipment itself. Fig. 9 shows what actually happened to the load on account of a thunderstorm last summer. The increase was not only excessive, but the rate of increase necessitated almost instantaneous action.

FREQUENCY CONTROL

Frequency control is an item of operating procedure which has been given considerable attention in the past few years. Previously standard frequency had been a term which was frequently referred to but which was realized by relatively few companies. The interconnection of large systems brought the

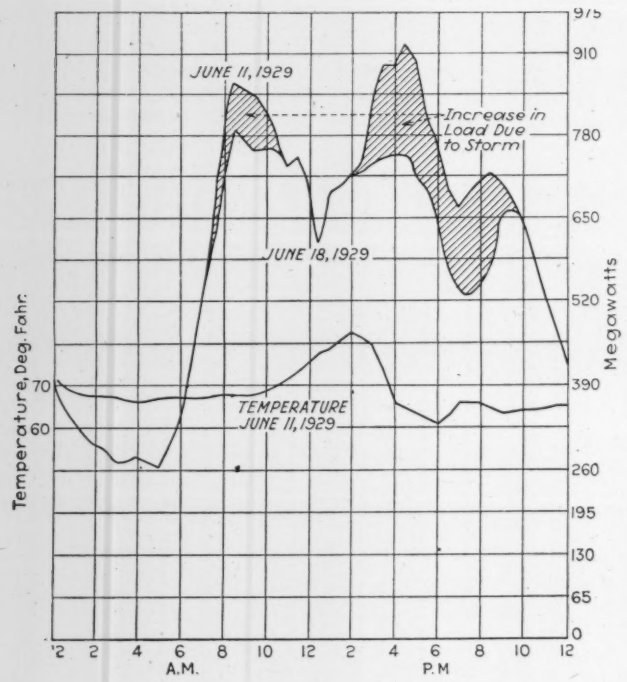

FIG. 9 INCREASE OF LOAD DUE TO STORM
(Commonwealth Edison Co.—Load diagram for total system.)

subject to the front, however, and made it necessary for all those interested to improve frequency conditions and to operate as nearly as possible on perfect time.

It is understood of course that perfect frequency will maintain perfect time, and as soon as the former was approached, various companies all over the country started selling "time" by the introduction of telechrons. The improvement in frequency regulation was indeed marked, and automatic frequency controllers appeared in numbers. Many operating companies developed their own, as we did, and the results were exceedingly gratifying, to say the least.

Fig. 10 is reproduced from a chart taken from the frequency recorder at a time when 45,000 kw. was suddenly dropped by one of the generating units, and shows not only the frequency of the system but the drift from perfect time as supplied by the U. S. Naval Observatory. It is now possible to operate for considerable periods with the frequency maintained within 0.05 cycle of standard, while the time rarely deviates as much as 2 sec. from

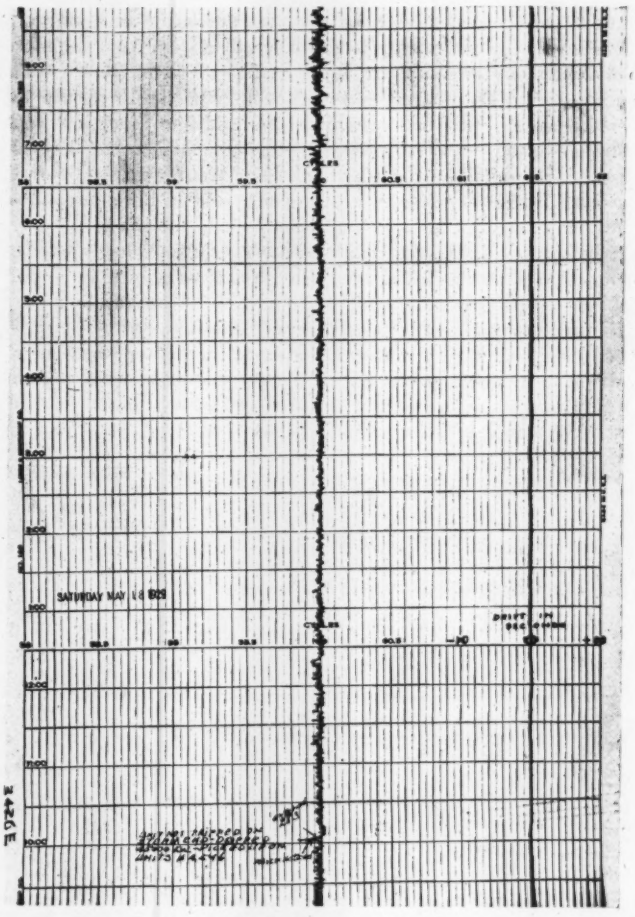

FIG. 10 CHART FROM FREQUENCY RECORDER SHOWING FREQUENCY OF SYSTEM AND DRIFT FROM PERFECT TIME AS SUPPLIED BY U. S. NAVAL OBSERVATORY

perfect time. Such close governing minimizes load drifts and tie-line disturbances between stations.

BUS SECTIONALIZING

As previously explained, the stations were connected first with a 33-kv. and then with a 66-kv. trunk tie line, which replaced a similar system of much less capacity that operated at generator voltage. Distribution from the stations, however, is radial and operates at 12 kv., which is the generating voltage. The long transmission lines connecting the wholesale power centers are operated at 132 kv.

As a matter of operating precaution the generating-station bus is sectionalized, in some cases with reactors, and lines to a given substation or to a large industrial customer emanate from more than one generating station. In all cases the lines may be connected to either one of two buses in such a way that either may be killed without interrupting the supply to the substation.

A further step is the equipping of buses with relays so that in case of trouble the buses will be sectionalized and the trouble isolated.

The isolated-phase type of bus construction has become standard practice in our newer installations. This is a purely protective measure, as it reduces the liability of phase-to-phase short-circuit. It is very improbable that such a fault would ever develop, except possibly by the simultaneous failures of two pieces of apparatus on different phases.

The urge for greater protection and better regulation is resulting in the speeding up of circuit breakers so that they will clear cable faults within two cycles ($^1/_{30}$ sec.) after the fault develops. On recent tests, air breakers cleared short-circuits within two cycles when the current value was 30,000 amperes at 12,000 volts, supplied by the main Chicago generating system.

PERIODIC TESTING

A feature of station operation which has become almost standard practice is the periodic testing of equipment and the institution of regular schedules for inspection and overhauling. With large units, such as those now in use, it is economically possible to instal sufficient indicating and recording instruments to keep a very accurate check on the performance of an individual piece of apparatus and to detect very quickly and definitely any feature of operation which is out of the ordinary. While these do not tell the whole story, tests may be conducted from time to time, and in the case of turbines and generators they may be opened up for inspection at regular intervals.

Boiler equipment is taken out of service at regular intervals for cleaning and for the inspection of auxiliaries as well as of the boiler itself, and these schedules are strictly adhered to in order to insure the safe and economical operation of the equipment. These precautions have of course a marked effect on the reliability of the equipment.

Periodic tests of feedwater, condensate, make-up, boiler water, lubricating oils, and the countless details which go to make up station operation—each has a place in the operating program. All of these make for reliable and economical operation.

RESEARCH

At the expense of being accused of going far afield, the author would say that the extensive research which has been carried on by operating companies and manufacturers in the last decade has been responsible not only for the improvement in the economical performance of generating equipment, but also in its reliability. On the part of the manufacturers there has been the work in metallurgical chemistry, resulting in the production of alloys which will withstand high temperatures and still retain the strength necessary for the high steam pressures which have recently marked a step in the economical production of power. Improvements in materials for generator construction are in the same class, and the determination of the performance of materials under stresses of various kinds has enabled manufacturers to eliminate serious troubles which would cause interruptions to service later on.

Because of this work, unit capacities have increased, economical performance has been improved, and unit cost decreased; and in spite of it all, reliability has increased, as has been quite clearly shown by the reports of the Prime Movers Committee of the N.E.L.A., and the Power Generation Committee of the Association of Edison Illuminating Companies. The reports of the mechanical and electrical engineering societies are additional proof of this development.

The operating companies themselves have found it advisable to encourage and in some cases institute research on operating problems. Improvement in feedwater conditions has been necessary and fundamental in the development of increased boiler capacity and efficiency, as well as in the performance of steam turbines. Boiler-furnace refractories have come in for their share of attention, as well as the harmful effects of corrosive agents in the fuel burned. All of these items, quite directly, have an influence on the reliable production of power and the ability to carry load safely and economically.

PERSONNEL

There has likewise been a great change in the personnel of operating departments. Many of us can well remember the time when a technical education was considered a handicap to any ambitious young man in the power-generating field. He was looked down upon by his associates. Every chief engineer was supposed to qualify originally on a scoop shovel and a wheelbarrow; then later on he became proficient with a slice bar, and from that was graduated to the oil can and finally to the switchboard. The shovel, the wheelbarrow, and the slice bar have disappeared from the picture, so far as large stations are concerned, and this potential source of chief engineers is now lacking. The man who can run a boiler room successfully nowadays must be well grounded not only in thermodynamics but in chemistry. The head of the electrical division must be equally well educated and proficient in his ability to understand both the theory and practice of the construction and operation of his equipment, and the turbine-room engineer should be a specialist in his particular line. All the men, in addition to their education, must be specially trained for the work in which they are to be engaged so that they will understand the equipment over which they will have supervision. This training must include a thorough understanding of the importance of personnel and the relation of this feature to the final operation.

Operating conditions in power stations are changing rapidly. A decade ago it was necessary to hire men who could not get a job elsewhere, as working hours were long and holidays were unknown. As mentioned before, week ends were a nightmare. Fortunately this is all in the past, and these men now work reasonable hours. Their weekly day off is assured, even though it may not be a Sunday, and they are generally sure of a vacation with pay, which they can enjoy with their families. Working conditions have improved immeasurably, and much of the dirt and sweat of the job has disappeared. Stations are clean, the standing of the power-house operative has improved immeasurably, and, because of the steady employment, good wages, and the privileges he enjoys, he is often envied.

SAFETY

In the "good old days" the engineer's badge of office was one or more missing fingers, and when in hiring a man he told you he had been an oiler for ten years, you instinctively looked at his hands to see whether or not he was telling the truth. Fortunately that, too, is a thing of the past, but in spite of the improvement in design of the equipment and the countless safeguards which have been installed, there are still plenty of opportunities for careless men to get hurt. The great reduction in the number of accidents, however, has been due very largely to the change in the attitude of the men themselves toward the "safety first" idea. Two of our stations, with a total of about five hundred men, went through the year 1929 without a single lost-time accident, and the improvement in the record of the department as well as the company as a whole was very marked.

BETTER MEN

The improvement in working conditions, working hours, and wages has resulted in a better class of men being attracted to operating work. Operating positions are more in demand, and better men are not only being attracted to them, but the incentives offered induce them to stay in the organization, once they enter the service. Because of their training and experience with

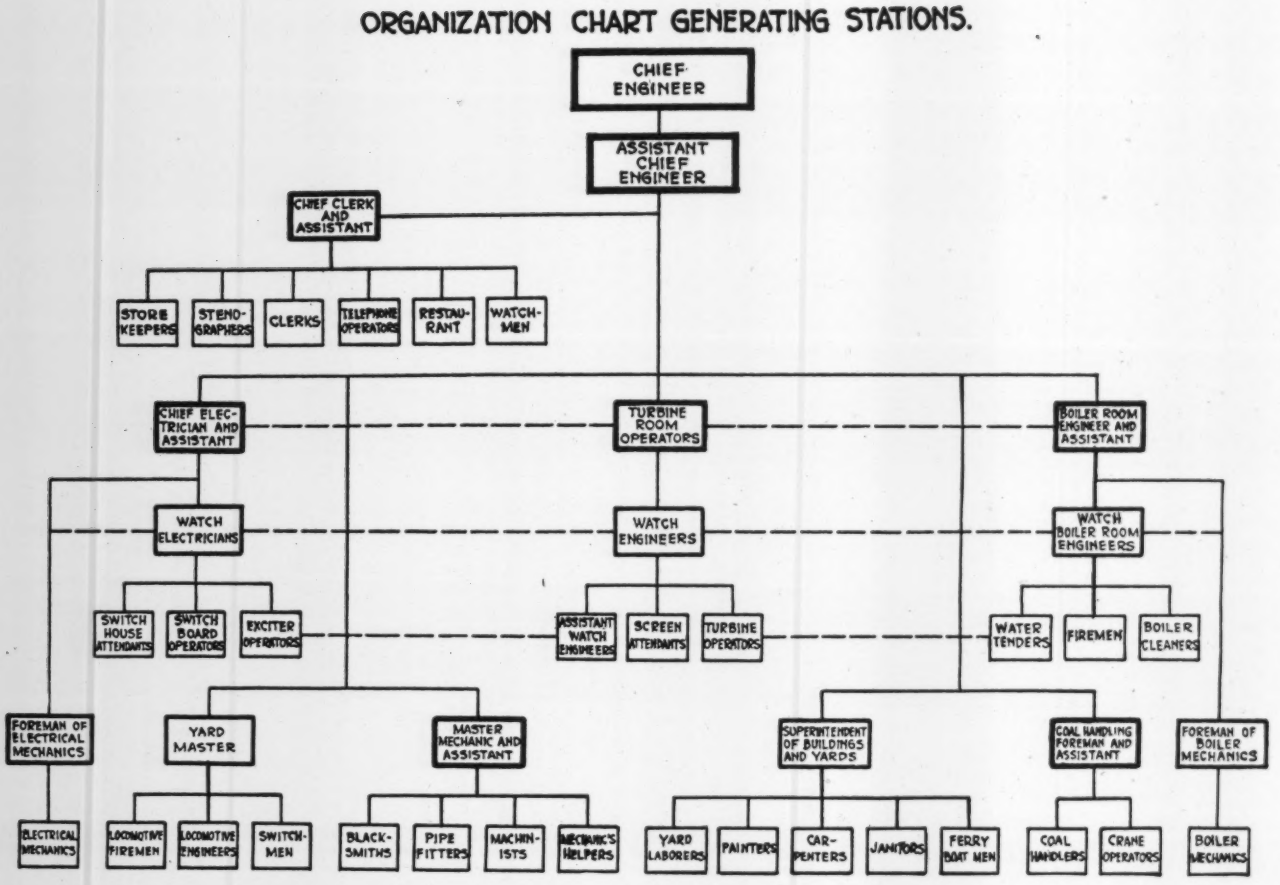

FIG. 11 CHART SHOWING STATION ORGANIZATION

the organization they have a better understanding of the company's business and its problems in a general way, and particularly of the equipment which they have to handle. They are thus better able to analyze conditions and to obtain the maximum of reliable operation and efficient performance. They have a pride in the organization as a whole, and in the particular department with which they are connected.

Due to the size of the system and the amount and complexity of the equipment to be handled, the opportunities for operating errors are numerous. During the year just closed there were over 88,500 switching operations performed on the station buses and high-voltage lines, in addition to those necessary for auxiliary power used in the stations. The total number of errors made was three, none of which was of a serious nature. On the other side of the picture, the estimating of the output and expense for budget-making purposes is extremely accurate. The actual output is frequently within one per cent of the estimate, and the generating cost per unit of output has been within one-half of one per cent.

The station organization, shown in Fig. 11, is as simple as it can be made. Each station is a unit complete in itself, the chief engineer in charge being responsible for the performance of all the equipment in the station.

CONCLUSION

The foundation for "carrying the load" a year from now, or five years from now, is being laid today, and the reliable and economical performance of our electric supply systems stand, not upon snap judgment and quick decisions made on the spur of the moment, but upon study in advance, with a full understanding of the conditions to be encountered and of the equipment to be operated. A good operating force cannot be picked up and made to perform effectively at once. Years are required to perfect such an organization. *Esprit de corps* comes from pride in one's company and its accomplishments, and is founded on long association. The performance of today is the result of work done years ago, and our reputation in the future will be governed by our ability to take care of emergencies in advance, and to anticipate in every way the requirements of the service.

In the near future a 1000-hp. air-cooled engine will be required for both military and commercial work, and it is believed that the compression-ignition engine has a considerable future. So much has been promised for the compression-ignition aero-engine of late years that there is some skepticism concerning it. It would appear that to cope with the additional stresses of a compression-ignition engine the specific weight will have to be at least 50 per cent higher than for the corresponding petrol-engine, and for power units of 800 hp., or under, this is a very serious consideration. There is also the question of smell, and creep from the fuel, and it is expected that this type of engine must run comparatively roughly, with serious effect upon such a light structure as an airplane. When, however, one considers the requirements of a large aircraft remaining in the air for considerable periods, where the lower fuel consumption of approximately 25 per cent would be of the utmost value, it is believed that the compression-ignition engine will come into its own.—A. H. R. Fedden, in *Engineering*, July 11, 1930.

The Statistical Element in Mechanics of Materials

The High Importance of Recognizing the Statistical Element in the Picture of the Internal Structure of Material and of Stress Distribution When Interpreting Mathematical and Experimental Results and in Formulating More Reliable Rules for Design

By FRED B. SEELY,[1] URBANA, ILL.

THE subject of mechanics of materials has been an important influence in our industrial and social development. It has been a guide in an approach toward a rational, safe, and economical use of materials in structures and machines that have done much to develop our manufacturing and transportation, and to extend our social contacts and pleasures.

In order to adapt the subject to the present and future demands of industry, however, we need to make adjustments in our thought concerning the internal actions in materials. In recent years there have occurred radical changes in our thinking in nearly all fields of physical science. In the field of mechanics of materials the newer ideas have not been so dramatic as in some of the other fields, yet they are gradually bringing about important changes in our thought.

Mechanics of materials or "strength of materials" is that branch of engineering concerned with the determination of *significant* stresses and strains in members used in structures and machines. The engineer seeks to determine values of stress and strain that indicate the extent to which the full utilizable capacity of the member is developed when subjected to loads, or that indicate the extent to which the member has progressed toward structural damage.

In the development of both the method of thought and the analytical tools for determining these internal effects in members, mathematics has had a great influence. In fact, the rapid development of the subject dates from the mathematical formulation by Navier, St. Venant, Rankine, and others, approximately one hundred years ago, of the main problem involved.

In the mathematical analysis of stress and strains, the material has in general been thought of as continuous, homogeneous, and isotropic; the calculated stress, for example, has in general been thought of as the actual stress *at a point* in the body. In other words, it has been considered that the material is capable of being subdivided indefinitely without losing any property which it exhibits in bulk, and that the stresses on any section of a member are distributed according to an exact (mathematical) law.

The picture of material as continuous, homogeneous, and isotropic that accompanied the mathematical development of the subject, soon came to be accepted rather generally as a true picture. Engineers in general have looked on it with confidence, especially in relation to metals, and particularly to steel, which has been used so extensively. The satisfactory agreement of calculated results and early static-test data seemed to justify this confidence. Further, the apparent complete success in the construction of machines and structures designed on the basis of mathematical analysis of stress and strain seemed to give final authority to the essential correctness of the picture.

Accompanying, and largely because of, this mental picture there has grown up a dogmatic confidence in the mathematical method of analysis of stresses and strains as used by the engineer and in the resulting formulas. Because the method and results have proved useful *under certain conditions*, they have been widely accepted as true and have been extended, sometimes with disastrous results, to conditions for which they are inadequate.

Inadequacy of Conception of Material as Continuous, Homogeneous, and Isotropic

In recent years, however, the inadequacy of this picture of material and of stress distribution has become evident, and the need for a modification thereof is being felt. Two conditions have largely been responsible in making this need felt. First, the introduction of high-speed machinery has caused material in use to be subjected to many millions of repetitions of stress, as in car axles, automobile crankshafts and springs, steam-turbine blades, airplane engines, etc., and the resistance of the material under repeated stress has been found to depend on quite different internal action from that under gradually increasing stresses.

If a bar of steel is subjected to a gradually increasing (static) pull in a testing machine and the stretch of the bar is measured, by means of some form of strain gage, it has long been known that the load per unit area (unit stress) and the stretch per unit length (unit strain) are approximately proportional (see Fig. 1) until a unit stress called the proportional (elastic) limit is reached. It has been very generally assumed that in any use of the material no structural damage occurs to the material if the calculated stress is less than the proportional limit, and that even if stressed considerably beyond the proportional limit the material is merely deformed but not broken. Fig. 1 shows a typical stress-strain curve for ductile steel and the value of the proportional limit.

Experiments and experience, however, have shown that stresses that are repeated a very large number of times frequently cause failure even though the calculated stresses in the member are less than the proportional limit of the material as found from a static test of the material. Thus not only does damage to material sometimes occur at calculated stresses less than those below which no damage was thought to take place, but the damage is accompanied by complete failure or breaking of the member. Further, the failure is even more disconcerting because the rupture usually comes with almost no warning or visible evidence of the approach of the disaster.

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Presented before Section M—Engineering, American Association for the Advancement of Science, Des Moines, Iowa, December, 1929.

In fact, the maximum calculated stress that a material can resist without breaking when the stress is repeated an indefinitely large number of times—called the "endurance limit" or "fatigue strength" of the material— shows very poor correlation with the proportional or elastic limit. Fig. 2 shows how the value of the endurance limit is obtained by plotting values of stress and the number of repetitions of stress required to cause rupture; it will be noted that a number of specimens must be tested to determine the endurance limit.

The proportional limit seems to be evidence of the beginning

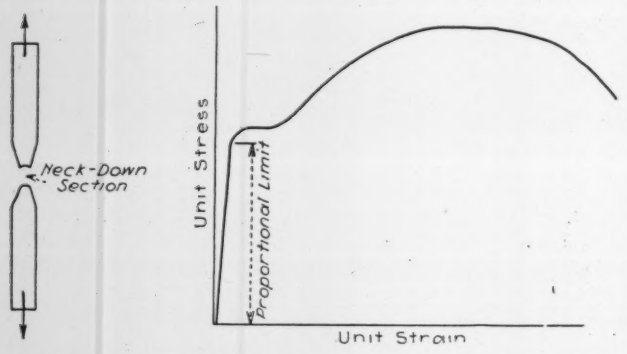


FIG. 1 STRESS-STRAIN DIAGRAM FOR DUCTILE STEEL

of plastic yielding in the material, whereas the endurance limit is associated with the tearing apart or rupture of the material. *Very different mental pictures of the internal actions occurring in a material evidently should be created in connection with these two terms.* The failure of the material due to repeated stress seems to start at some point of high concentration of stress due to an internal discontinuity, such as a small flaw or crack, or to an external discontinuity, such as an abrupt change of section, and to spread gradually until the member breaks in two. In this process the understressed material has but little chance to aid the overstressed material; *the failure progresses as a local effect.*

STATIC FAILURE A PROCESS THAT INVOLVES ACTIONS OF A LARGE NUMBER OF ELEMENTS OF A MEMBER

On the other hand, in the failure of the material under a gradually increasing (static) load the same concentrations of stress may occur, but the high stress is transferred to surrounding understressed material as the material at the points of high stress yields, and although the static failure is in some degree a gradual process, *it is a process that involves the actions of a large number of elements or units of the member,* even though the units vary widely as to size and shape, and are so disposed as to have a random orientation.

Figs. 3 and 4 illustrate the difference in the type of failure of two similar steel rods caused by gradually increasing (static) loads and by loads (of considerably less magnitude) repeated many times. Under a gradually increasing load the member yields as it fails, whereas under repeated loading the member fractures without appreciable deformation.

Fig. 5 is a view of the ruptured section of a steel that failed under repeated bending stress; the failure started at the outer surface and the fracture gradually spread until the area was reduced so much that the remaining metal broke rapidly, giving the appearance of a rough crystalline core. Failures of car axles, steam-turbine blades, automobile and airplane parts, etc., sometimes accompanied by much damage, have furnished compelling evidence of the need of a more detailed knowledge of the internal actions in materials in resisting repeated stress.

The second condition that has helped to destroy the dogmatic confidence in the picture of materials as continuous and homogeneous, with the accompanying picture of regularity of stress distribution, has been the development and use of the metallurgical microscope as a tool of the testing laboratory. A section of a metal, such as steel, for example, when etched and viewed through the microscope is revealed as a highly heterogeneous aggregation of irregular crystalline grains (see Fig. 6). The view at once suggests a very irregular stress distribution on any section of the member. The haphazard arrangement or orientation of the crystals strongly suggests that high concentrations of stress probably occur where the sharp edge of one crystalline grain bears against the flat face of another, and at the ends of minute cracks or flaws; that some of the crystalline grains are strong, some weak, some so placed as to offer large resistance to internal forces in one direction and small resistance in another, some perhaps with planes of least strength coinciding with planes of maximum calculated stress, and some with planes of maximum strength coinciding with those of maximum calculated stress, etc.

INTERNAL ACTIONS IN MATERIALS EVIDENCED BY SLIP PLANES

Experimental evidence of internal actions consistent with those pictured in the preceding paragraph is found in the development

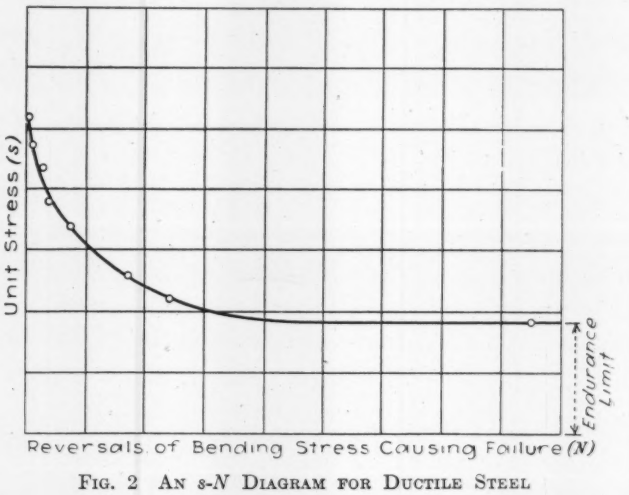


FIG. 2 AN *s-N* DIAGRAM FOR DUCTILE STEEL

of "slip planes" in an increasing number of crystalline grains as the load on a specimen is gradually increased. A slip plane is caused by the sliding of one portion of a crystalline grain on another part along (probably) a plane of weakness or a plane of high stress, and is evidence of yielding. Thus in Fig. 6, which shows micrographs of steel, slip lines can be seen only in one crystalline grain, on the particular section viewed, when the member as a whole was not heavily stressed [Fig. 6(*a*)], but several more grains show yielding and the number of slip lines is increased when the member is gradually stressed considerably beyond the yield point.

Some engineers on seeing through the microscope the crystalline structure of a metal and on contemplating the nature of failures due to repeated stress, are likely to feel that the foundations of the whole mathematical theory of elasticity as applied to actual metals have been swept away and that they may as well abandon all their formulas built on the basis of homogeneous material and regularity of stress distribution.

Some day there may be built up a form of molecular or atomic mechanics by means of which we may determine the condition of stress and strain at a point (within a single crystal of metal, for example). At present we do not know the nature of the cohesion of the particles of a solid, and hence we must deal with material more or less in mass. In short, our mathematical values of stresses and strains are largely statistical values.

The statistical nature of the problem may further be brought out as follows: Formerly, with the picture of continuous, homogeneous material in mind, it was thought that the material at any point was not damaged (and certainly not ruptured) at any stress less than the proportional limit. We are now beginning to think of the value of the proportional limit merely as a statistical value representing the average of the stresses in a very large number of elements in an aggregate, between which elements

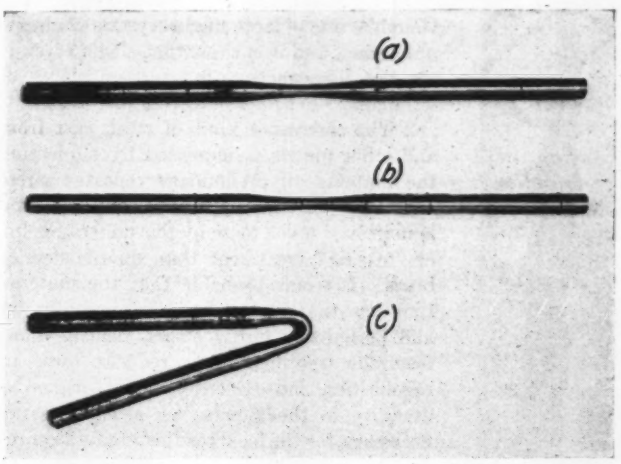


FIG. 3 FAILURE OF STEEL SPECIMEN IN BENDING DUE TO REPEATED REVERSED LOAD AND TO STATIC LOAD

(*a*) Original specimen.
(*b*) Specimen subjected to repeated reversed bending moment.
(*c*) Specimen subjected to gradually increasing (static) bending moment.

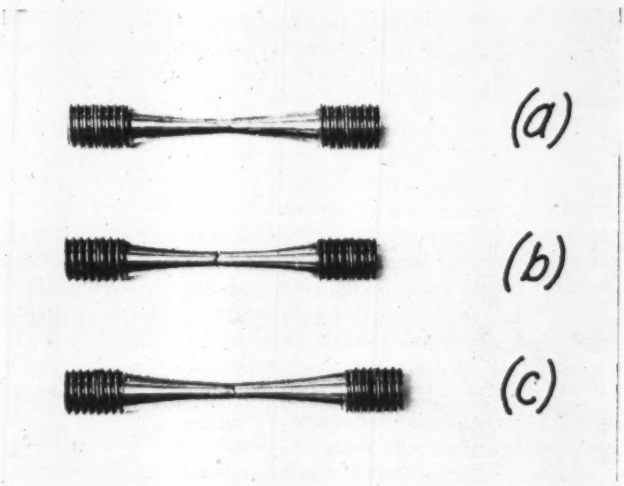


FIG. 4 FAILURE OF STEEL SPECIMEN DUE TO REPEATED REVERSED AXIAL LOAD AND TO STATIC AXIAL LOAD

(*a*) Original specimen.
(*b*) Specimen subjected to repeated tensile load (approx. 1/2 static ultimate).
(*c*) Specimen subjected to gradually increasing axial tensile load.

there are mutual adjustments. These adjustments which play such an important role in the resistance of materials subjected to static loads, and which in a large measure cause the calculated values of stress and strain due to static loads to be significant values, may be pictured in a rough way as follows: When a small load is applied to a bar a number of crystalline grains that are weaker than the others, or that are so oriented that their planes of weakness coincide with planes of maximum stress, or that are subjected to intense local concentrations of stress due perhaps to minute flaws, yield locally without measurably affecting the deformation of the member as a whole. This yielding causes local readjustments in the stress distribution, permitting the material in the immediate neighborhood of the damaged crystals to take additional stress. With increasing load on the specimen more and more local yielding and readjustment of stress in various groups of crystals takes place, the deformation becoming measurable in the specimen as a whole only after a large number of crystalline grains have yielded simultaneously. And for any given metal made according to a given process, this general yielding occurs at approximately the same calculated stress.

PROPORTIONAL LIMIT OF A DUCTILE MATERIAL PREDICTABLE SATISFACTORILY FROM TEST OF SAMPLE SPECIMEN

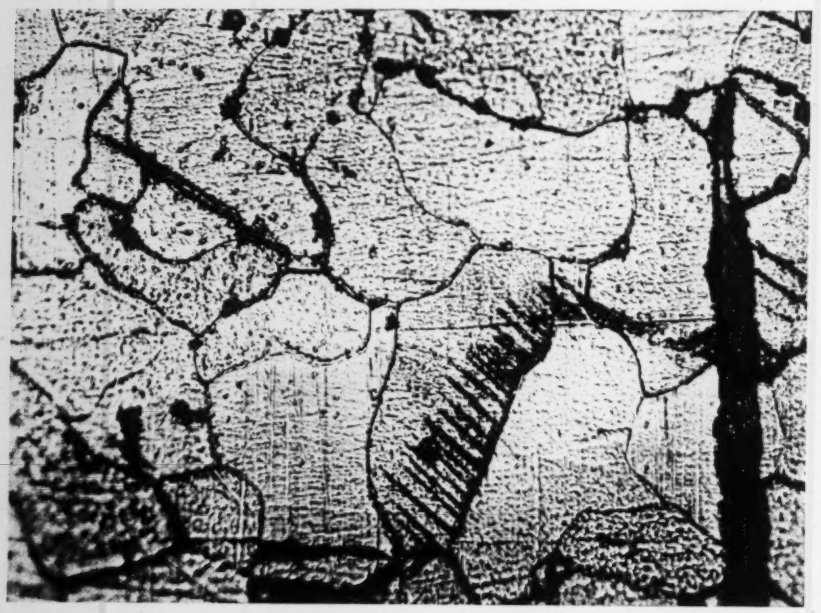
We are able to predict with satisfactory accuracy the value of the proportional limit of a ductile material, such as rolled steel, from a test of a sample specimen for much the same reason that we are able to predict by use of mortality tables the number of

FIG. 5 VIEW OF FRACTURED SECTION OF STEEL SPECIMEN BROKEN BY REPEATED REVERSALS OF BENDING STRESS

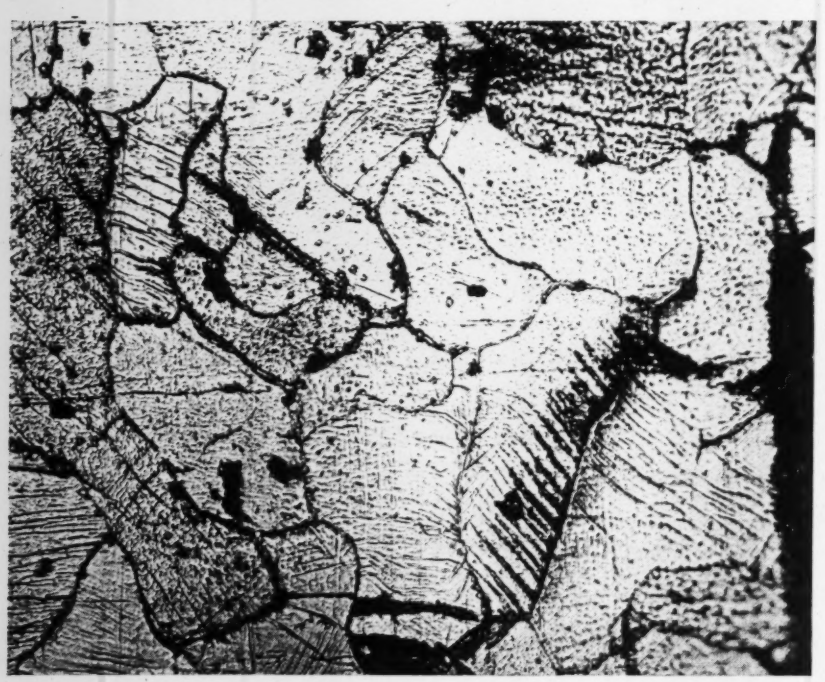
people in a large group (human aggregate) who will die in a given period, provided the group is living under approximately the same conditions as those for which the mortality tables were constructed. A widespread epidemic, war, etc., may cause a relatively large error in the prediction; similarly, excessive nonmetallic inclusions, defects due to segregation, unusual orientation of crystals due to cooling conditions or previous overstrains, etc., may influence the statistical behavior of the aggregate of metal and thereby markedly influence the value of the proportional limit. As commonly manufactured, however, the size and orientation of the crystalline grains, the size and distribution of inclusions and defects, the values and distribution of initial stresses, etc., are governed by probability and chance, and a statistical value of the aggregate becomes a reliable predictable property of any aggregate manufactured by a given process and tested under standardized conditions, although the action within a crystalline grain at any particular location in the specimen when resisting a given load is entirely unknown.

In attempting to visualize the behavior of the material as described above, it may be helpful to observe the effects on the

stress-strain curves of steel of arbitrarily putting discontinuities in the steel in the form of small drilled holes. Fig. 7, which is self-explanatory, gives evidence of local effects and readjustments when discontinuities are arbitrarily exaggerated. Further evidence of discontinuity, non-homogeneity, local actions and readjustments, etc., are found in the following experimental results:



(*a*) Metal subjected to a few cycles of stress slightly above the yield point.



(*b*) Same metal after being given 12 per cent permanent elongation.

FIG. 6 SLIP LINES IN ARMCO IRON BEFORE AND AFTER PLASTIC DEFORMATION. × 390

1 The ultimate strength of ordinary structural steel, as found by pulling it apart in a testing machine, is approximately 65,000 lb. per sq. in. based on the original area, or about 120,000 lb. per sq. in. based on the area of rupture. If, however, the strain energy at rupture were of the same order of magnitude as is the heat of vaporization, as required by the molecular theory, the ultimate strength of the steel would be ten to twenty times the test value. This difference, probably, in steels as manufactured is due mainly to the inherent discontinuities in the form of a network of minute cracks which weaken the cohesive forces or atomic bonds between the elementary parts. In fact, Zwicky calls attention to theoretical reasons for the necessity of microscopic cracks even in the most perfect crystals. And Gough's tests of large single crystals of aluminum, zinc, and iron show that single crystals are not homogeneous but possess planes of weakness.

2 The endurance limit of steel, cast iron, and other metals is increased by subjecting the material to preliminary repeated stress less than the endurance limit, and cast iron is improved much more by this understressing or "teasing" treatment than ductile steel or brass. It seems probable that the material that has the greater degree of discontinuity and perhaps of initial stress, benefits most from the treatment that reduces these irregularities, and evidently a high degree of ductility in the member as a whole is not necessary for the local readjustments required to increase the fatigue resistance.

3 If steel is heat treated so as to give increased strength, which may be assumed to be due at least in part to increased homogeneity or lessened internal discontinuities, its strength is decreased more by localized stress caused by abrupt changes of section than is weaker (and presumably), less homogeneous steel. Likewise cast iron, which is relatively discontinuous and heterogeneous, is weakened by localized stresses due to external discontinuities much less than is steel.

Apparently metals that possess the greatest number of internal discontinuities and concentrations of stress profit most by having the irregularities decreased, and are injured least by additional irregularities. Likewise metals that are relatively free from discontinuities and concentrations of stress cannot be greatly improved, but are materially injured by the introduction of discontinuities and concentrations of stress.

We may find it helpful sometimes to picture material as being continuous but non-homogeneous and non-isotropic, or as being homogeneous and isotropic but discontinuous. In any case, however, it seems clear that concentration of stress at numerous points throughout the body (irregularity of stress distribution) is an essential part of the picture, and it also seems clear that the problem is one where exact calculations can have no place and that occurrences are governed by probabilities.

For example, the stress on a cross-section of a tension member subjected to an axial load is probably distributed irregularly as shown by the irregular line in Fig. 8 instead of uniformly as is assumed in the usual theory. Likewise the stress distribution on a section of a beam varies not directly as the distance from the neutral axis but in some irregular way as suggested in Fig. 9.

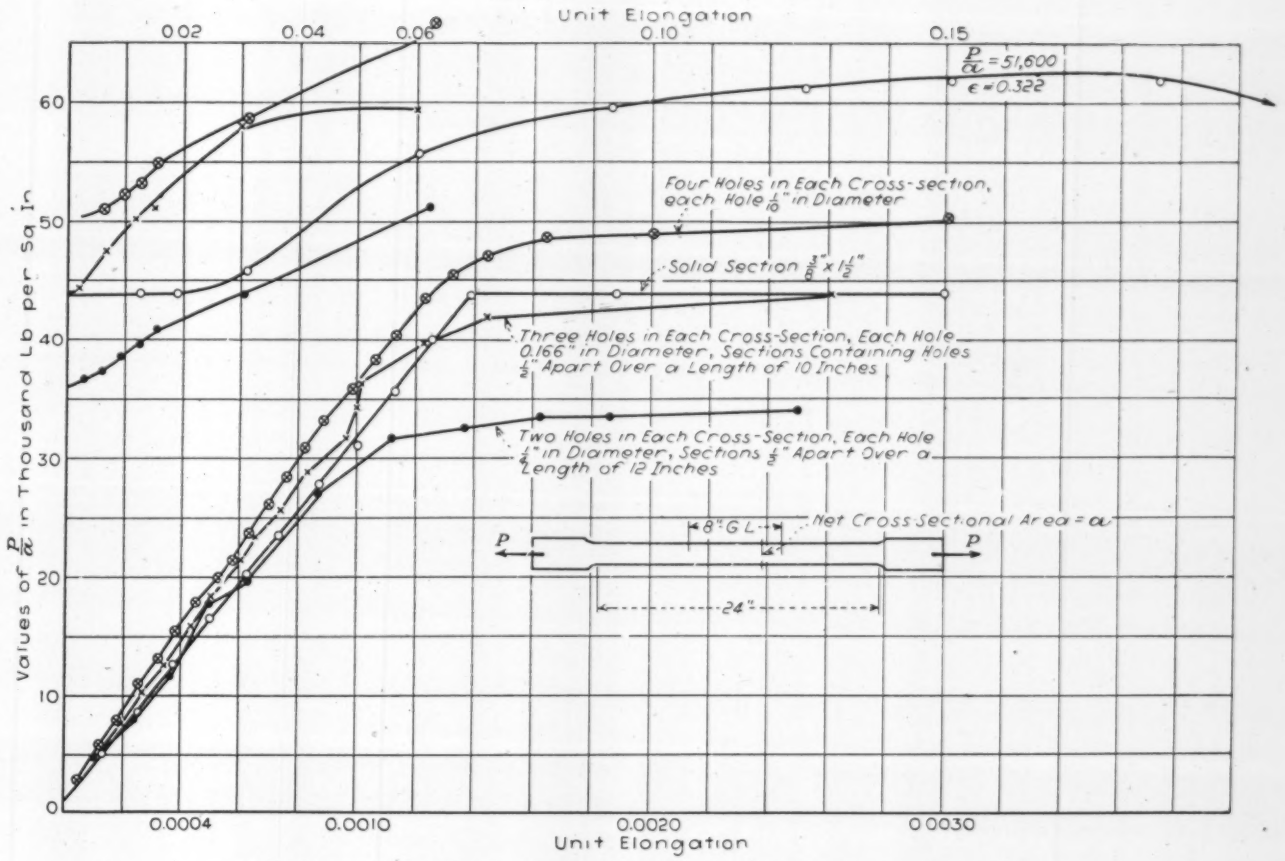


FIG. 7 EXTENSOMETER TESTS OF DUCTILE-STEEL SPECIMENS WITH AND WITHOUT HOLES

ASSUMPTION THAT THE MATERIAL IS CONTINUOUS, HOMOGENEOUS, AND ISOTROPIC LEADS TO RELIABLE FORMULAS

The question now naturally arises: Do all engineering materials under the same type of loading, or any one material under all types of loading, act so that calculated values of stresses are reliable values in estimating the resistance of the material to the extent to which the utilizable capacity of the member is developed? This question from the engineering viewpoint must be answered largely by experiment and experience. In a general way it may be stated that *for ductile material subjected to approximately static loads, the calculated values of stresses are the significant values,* because the internal adjustments, made possible largely because of the ductility of the elements of the aggregate, cause failure to be a phenomenon involving the properties of a large number of the units in the aggregate. In other words, under the conditions stated the material acts so that its statistical properties are significant properties, and the assumption that the material is continuous, homogeneous, and isotropic leads to formulas that give reliable results, even though the discontinuities are rather severe.

If, however, a failure starts as a microscopic crack, due perhaps to the failure of a single crystalline grain, or as an initial flaw, and gradually spreads, as seems to be the case with repeated stress, then *insufficient material appears to be involved to make the statistical value of the stress or of the properties of the material as obtained from a static test a reliable indication of the utilizable capacity of the member.* For experiment and experience show that failure of members under repeated stress often occurs at calculated stresses that the material successfully resists without damage when subjected to static loading.

Likewise calculated values of stress for brittle material, even though the material is subjected to static loads, are less reliable

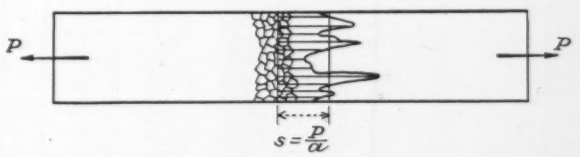


FIG. 8 PROBABLE STRESS DISTRIBUTION IN TENSION MEMBER

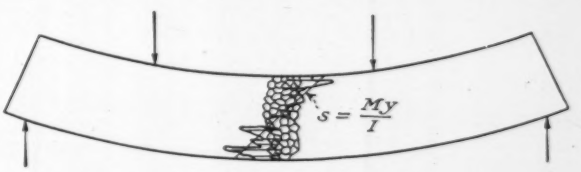


FIG. 9 PROBABLE STRESS DISTRIBUTION IN BEAM

than for ductile material. Static tests of specimens of a brittle material such as plaster of paris, even when the material is mixed, cured, and dried under presumably the same conditions, give much wider variation in the strength of the material than is found for ductile material. However the statistical values found by averaging the results of a number of tests are consistent. In such a material the fortuitous stress concentrations can be relieved to a much less extent, and hence they play a larger part in determining the strength of the specimen; the resulting test value of a single specimen is therefore to a less extent a statistical value of the aggregate than in the case of a test specimen of ductile material.

A static test of a ductile metal may be thought of as simultaneous tests of a very large number of small elements the average of whose strength is obtained by virtue of a mechanical process involving internal adjustments in which the stronger and less

stressed elements help the weaker and more stressed elements; a brittle material can to a much less degree take advantage of this mechanical process, hence to obtain a corresponding statistical value a number of specimens must be tested and an average of the results obtained *mathematically*.

It is evident that in most materials the conditions of stress and strain in elementary parts or units of structure are extremely irregular and are impossible of exact mathematical analysis. It may be possible, however, that helpful contributions may be made through statistical methods in determining the effects of variations in the stress conditions in the elementary parts by dividing the members arbitrarily into parts and assigning different properties or planes of weakness to the parts distributed according to laws of chance.

PROGRESS DEPENDENT ON CAREFUL EXPERIMENTATION

It seems clear, however, from both the nature and the extent of the statistical element in mechanics of materials, that mathematical analysis of stresses and strains in engineering materials can be made at best only a basis for convenient rules for guiding our dealings with those materials, and that progress in the subject is becoming more and more dependent on careful experimentation as new materials are introduced and as old ones are put to new uses.

In this connection it should be stated that in all cases of stress concentration for which it has been possible to obtain by mathematical analysis a value of the localized stress, as, for example, the stress at the edge of a circular hole in a plate, the value appears to be on the safe side; that is, in the mathematical analysis the effect of the discontinuity which causes the stress concentration is overemphasized.

In the development of more reliable rules of design, the kind of mental picture set up of the internal structure of material and of the stress distribution in members is of great importance. It has been one of the objects of this paper to present a picture that will make the interpretation of both mathematical and experimental results more meaningful and reliable than is likely to result from the conception of ideal material and of regularity of stress distribution that has been too common in the past.

Probably to the mathematician the problem of determining the significant stresses and strains in a member composed of an aggregate of structural units is not a satisfactory statistical problem, since sufficient knowledge about the structure units of the aggregate is seldom available to make it possible to use mathematical statistical methods.

Similarly, the engineer is likely to give too little consideration to the statistical element in the problem largely because it does not, in general, lead to a direct method of calculating stresses, and hence appears to be an indefinite element in the problem. But our propensities to idealize all situations in order to apply methods that lead to definite results, have in the field of mechanics of materials led to a false sense of security. A recognition of the statistical element in the picture of material and of stress distribution is becoming of great importance in the interpretation of mathematical and experimental results, and in the formation of more reliable rules for design.

If all those machine and structural members that have failed in service primarily because their design was based on a conception of the material as continuous and homogeneous and of stress distribution as mathematically regular, could be assembled at one place it is quite likely the size of this "scrap heap" would be impressive. The corresponding economic loss and perhaps the loss of life would also probably be very large. In attempting to build up a more useful and reliable picture of material and of stress distribution, we are not dealing merely with an academic problem.

Arc Welding in Industry

THE metallic arc welding of structural-steel buildings and bridges is now well past the experimental stage. Their design can be carefully calculated in advance and many well-defined advantages and economies can be realized through its use. Because of these definite advantages its use is rapidly increasing. A structure designed for arc welding permits the use of less metal to withstand a given stress. This means a saving in the cost of material and a reduction in the weight on the foundations, permitting greater heights. In a riveted building, larger sections are necessary because rivet holes are responsible for a certain loss in strength. Gusset plates and angles at joints are not required in a welded structure, since the members may be directly connected to each other. Statistics show that the savings in steel range from 10 to 43 per cent by the substitution of arc welding for riveting. This wide variation is accounted for by differences in design and construction employed in various structures and by various engineers.

One of the big advantages of arc welding for buildings erected in cities is the elimination of the riveting hammer, ever a source of annoyance. Any one who has lived or worked near the scene of a building operation will appreciate this. A case is on record where a judge in a district court ordered the stopping of building operations in which riveting was used, so that he might hold court. Arc welding has changed all this and buildings can now go up silently and quickly.

Three types of construction are used on pipe lines: (1) the most commonly known screwed-fitting type involving threaded pipe and couplings; (2) the Diesser coupling method of connection; and (3) the newer development, plain steel pipe with welded joints. Arc-welded joints have proved absolutely reliable and much cheaper than any other type. This method is therefore meeting great favor, especially in the oil fields. The use of arc welding in this field is comparatively recent, but since its adoption its growth has been very rapid. The first completely arc-welded pipe line was laid in 1926. It proved to be a tremendous success and interest in pipe-line welding rapidly increased. At the present time there are many hundreds of miles of arc-welded water, gas, and oil pipe lines in service.

Metal containers are used in industry in vast quantities and in a great variety of forms. Some of the finest examples of automatic arc welding are found in plants making ice-cream cans and milk cans. Tanks include a great variety of containers, examples of which consist of underground gasoline tanks, city gas tanks, oil tanks in the field and in refineries, and tank wagons. Here, too, automatic arc welding has been particularly successful. Oil refineries and natural-gasoline plants utilize great numbers of arc-welded vacuum and pressure vessels. Producers of oxygen, acetylene, and hydrogen, together with oil refiners, have come to look upon welded joints as a practical means of reducing the hazards common to such plants.

In the manufacture of machinery, very radical changes in machine construction are being made through the adoption of arc welding. Welding shops are already on a par with iron and steel foundries, both in number and importance. Instead of using castings, machinery of widely differing classifications is being constructed by welding together plates, shapes, and premachined parts. This new construction economizes material and weight by utilizing the greater strength and ductility of steel plates, and thus reducing the sections required in castings.

In railroad work, it is found that fire boxes and boiler tubes replaced by arc welding stand up very successfully under hard service. Leaks of various kinds can be stopped by welding, with invariably good results.—H. M. French. in *Mining and Metallurgy*, July, 1930.

The Division of Aeronautics of the Library of Congress

Particulars Regarding This Extraordinary Assembly of Aeronautical Literature, the Rare Collections Acquired Through a Grant From the Daniel Guggenheim Fund for the Promotion of Aeronautics, Character of Service to Be Rendered by the Library, Etc.

By ALBERT F. ZAHM, Ph.D.,[1] WASHINGTON, D. C.

PRIOR to 1929 the Library of Congress had not endeavored to secure an extraordinary collection of aeronautical literature, nor to provide specialists to facilitate the public's use of the limited material on hand. No special fund as yet had been provided for the purchase or service of such material. Books and pamphlets obtained by copyright, exchange, or gift of persons and institutions had steadily accumulated; but no collections in bulk had been acquired. No concerted effort had been made to centralize comprehensively at any one national establishment either the ancient or the rapidly growing current literature of aeronautics, as obviously should some time be done in the interest both of scholars writing histories, treatises, or textbooks, and of active technical men—laboratory investigators, inventors, designers, engineers, administrators, manufacturers, transporters, pilots, instructors, lawyers, etc.—engaged in the scientific production, operation, and regulation of aircraft.

Accordingly various governmental branches had assembled independent aeronautic libraries, which entailed duplication of material and effort. Among these were the Smithsonian Institution, the Army, the Navy, the Department of Commerce, the National Advisory Committee for Aeronautics. Some of the departments had several aeronautical collections accumulated more or less at random. Besides these there were private collections of specialists, or of institutions. Such was the Octave Chanute collection in the John Crerar Library, Chicago; that of the Aeronautical Chamber of Commerce, New York City; that of the National Aeronautic Association, Washington, D. C.; etc.

The Guggenheim Grant

In January, 1929, the Daniel Guggenheim Fund for the Promotion of Aeronautics proffered to Dr. Herbert Putnam its cooperation in forming at the Library of Congress an aeronautical collection which eventually might become "the most important aeronautical library in this country, and perhaps even in the world."

Pursuant to the suggestions contained in the subsequent correspondence with officers of the Daniel Guggenheim Fund, Dr. Putnam invited to the Library, for a conference with him on February 26, representatives of the War Department Air Corps, the Smithsonian Institution, the Department of Commerce, and the National Advisory Committee for Aeronautics. The opinion expressed at the conference was unanimous that development of the proposed collection should be at the Library of Congress, and that other aeronautic branches of the Government should endeavor to strengthen it, avoid unnecessary duplication, and direct research to it.

Special stress was laid upon the need of expert service not merely to develop the collection but to interpret it and aid serious readers in its effective use. Besides the usual cataloguer, classifier, bibliographer, or reference librarian skilled in library mechanics, there should be in charge of the collection a specialist in the subject matter, a man combining advanced scientific and technical training with bibliographical knowledge, one accomplished in aeronautics as a science and familiar with its practice as an art.

Dr. Putnam, in his letter of February 28 reporting the conference to the officers of the Daniel Guggenheim Fund, emphasized that "only a specialist well grounded in the science and familiar with the methods of research in it, and also with an understanding of the operations involved in it as an art, which will enable him to keep in touch with such operations, in intelligent relation with those conducting them, can either develop the collection effectively or make it fully useful."

He further recommended that as much of the proposed grant as might be requisite be applied to the maintenance of a "Chair" of Aeronautics ("The Guggenheim Chair of Aeronautics"); and only any resulting surplus to the acquisition of material.

Dr. Corbin, in his report of the conference to the Secretary of the Smithsonian Institution, concluded: "The conferees were convinced that, if adequate means could be provided by the Guggenheim Fund for carrying out the two projects mentioned, the Fund would thus very materially advance the cause of aeronautics in the United States. They will look forward to its decision with the keenest interest."

Another result of the conference was the recommendation of the representation of the Smithsonian Institution that the Langley Aeronautical Library be transferred to the Library of Congress.

As a result of these preliminary negotiations the Library of Congress received, under date of October 29, 1929, a grant of $140,000 from the Daniel Guggenheim Fund for the Promotion of Aeronautics. Its application, as detailed in the Librarian's annual report for 1929, is specified as follows:

"For the endowment at the Library of a 'chair of aeronautics,' $75,000.

"For the acquisition of material, $51,000.

"For service during the interim (perhaps two years) before the creation of Government stipends for the chief of the section and an assistant, $14,000."

[1] Chief of Division of Aeronautics and Incumbent, Guggenheim Chair of Aeronautics, Library of Congress, Washington, D. C. Formerly professor of mechanics at Notre Dame University and at the Catholic University of America. Dr. Zahm served as chief research engineer of the Curtiss Airplane Company and as director of the U. S. Navy aerodynamical laboratory. He designed, equipped, and operated America's first wind-tunnel laboratory, and invented numerous aerodynamical instruments. He is the author of many treatises and papers on aeronautical subjects.

THE CENTRALIZED AERONAUTIC COLLECTION

Having received from the Guggenheim Fund assurance of a liberal grant, Dr. Putnam, in the spring of 1929, took steps to form an aeronautic division in the Library of Congress and to provide personnel and material for it.

The national library was now prompt to procure aeronautic collections by bulk or piecemeal; by purchase, transfer, gift, or bequest; to become the centralized depository, in the United States, for the most effective working material and for the most precious treasures—books, pamphlets, manuscripts, prints, engravings, autographs, original drawings, objects of art, etc.—garnered by enthusiasts throughout the world from time immemorial.

After negotiations in the spring of 1929, and later, the Librarian received from booksellers in London, four important aeronautical libraries. These are known respectively as: (1) the Tissandier collection; (2) the Hoernes collection; (3) the Silberer collection; (4) the Maggs collection. This combination was regarded as the finest available library of its kind that could be purchased anywhere in the world.

At the time of this purchase, in April, 1930, the whole aeronautical collection in the Library of Congress numbered as follows:

	Volumes and pamphlets
Original Aeronautical Collection in Library of Congress, April, 1930	3113
Gaston Tissandier Collection	1800
Hermann Hoernes Collection	783
Victor Silberer Collection	895
Maggs Brothers Collection	621
Samuel Pierpont Langley Collection	2115
	9327

The Tissandier collection is particularly rich in works on the early history of aeronautics, including many 16th- and 17th-century books by learned theorists—Lana, Borelli, Kircher, and others. It contains approximately all the worth-while aeronautic literature published in France up to 1900. It forms the subject matter of two books by Gaston Tissandier, and has furnished illustrative material to most French authors on the history of aeronautics. It comprises the whole collection of Dupuis-Delcourt, another airship constructor, which was accumulated before 1860 and later purchased by Gaston Tissandier. The complete Tissandier collection is the patient life work of the brothers Gaston and Albert Tissandier (famous balloonists, writers, and constructors of an electric dirigible), enriched by additions of Gaston's son, Paul Tissandier, "himself aeronaut and aviator, possessor of the most important library and the most beautiful aeronautic collection of the 18th century."

The Victor Silberer collection contains several long runs of periodicals and many books which the collector received as owner-editor of two aeronautic periodicals. Besides the modern books, there are several old and rare items, and many scarce pamphlets and reprints. Silberer's own books are naturally included. Born in Vienna in 1846, Silberer became prominent in Austrian civil and military aeronautics, was honorary member of several aero clubs, and made 147 balloon voyages.

The Hermann Hoernes collection comprises the material for writing Hoernes' three-volume handbook of aeronautics, "Buch des Fluges." Like the Silberer collection, it has many periodic sets and numerous reprints and clippings from periodicals. Born in Austria in 1858, Colonel Hoernes, at 30 years of age, was sent by the war ministry to study aeronautics in Germany, France, and England. He achieved distinction as a military aeronaut, writer, engineer, and inventor. Like Silberer, he was prominent in various aeronautic societies, and was the recipient of many decorations for meritorious service.

The Maggs Brothers, London booksellers, had issued in two parts a fine descriptive catalog of books, engravings, and autograph documents illustrating the evolution of the airship and the airplane; Part I in 1920, Part II in 1923. All of the 621 volumes that remained of this Bibliotheca Aëronautica in 1929, save 197 items duplicated in the collections of Tissandier, Hoernes, Silberer, were bought by the Library of Congress in 1930.

The Samuel Pierpont Langley collection comprises, first, the private aeronautical libraries of Langley and of James Means; and second, the accessions added by the Smithsonian Institution through purchase or exchange. It is especially rich in very complete files of important aeronautic periodicals.

As a whole, these five collections cover the accumulated results of aeronautic research and experiment from the earliest times down through the ages, till, after the development of the internal-combustion engine, they finally culminated in the production of practical airships and airplanes of immense commercial and political importance.

Among the notably precious antiquarian items in these collections one finds some original manuscripts of the Montgolfier brothers, inventors of the hot-air balloon; an original letter, dated November 21, 1783, of Benjamin Franklin to Sir Joseph Banks, describing and shrewdly appraising the spectacular first balloon ascension in history, made in a hot-air bag, September 27, 1783, by the Marquis d'Arlande; the original autograph manuscript report on the first hydrogen balloon ascent, read by the inventor and pilot himself, Prof. J. C. A. Charles, to the Paris Academy of Sciences in 1784; a score of beautifully illustrated balloon almanacs of early date; four separate editions of Giovanni Alphonso Borelli's "De Motu Animalium;" etc., etc.

Comparatively rare, too, and historically precious, are A. Goupil's "La Locomotion Aerienne" describing his invention, patented in 1883, of the modern three-torque system of airplane control; A. du Roy de Bruignac's "Récherches sur la navigation Aerienne," 1875, in which is presented analytical proof that a given smooth-gliding plane can be supported with less power at high than at low speed; works on balloons, free and dirigible, by Meusnier, Giffard, Renard, Tissandier, etc.; aviation books by Mouillard, Count d'Esterno, Professor Marey, etc.

CHARACTER OF SERVICE TO BE RENDERED

The Library of Congress is in part a bureau of information, in part an institution for comprehensive and systematic research.

In the first capacity it answers annually tens of thousands of inquiries addressed to it in manifold ways—by mail, telephone, telegraph or cable, by personal conference or messenger. These answers for the most part are made by citations of printed authorities, bibliographies, publications exhibiting material in the National Library or in other readily accessible places, such as various branches of the Federal Government or various local libraries. The questioner may also consult the library's material directly. "Any person from any place may examine within its walls any book in its possession, and may do this without introduction or credentials."

In the second capacity the Library of Congress furnishes both material and expert assistance to persons engaged in research apt to advance the boundaries of knowledge. Under the inter-library loan system it lends certain books to other libraries for the use of investigators engaged in serious research, thus rendering to scholarship a special service not within the power or duty of such local libraries. "It meets the unusual need with the unusual book." Furthermore, having special endowed "chairs," it may furnish to a few researchers such personal aid as is commonly rendered to advanced students in the universities.

Safety in Aerial Navigation Through Radio Communication

Results That May Be Expected From the Installation of Directive Radio Beacons, the Broadcasting of Weather Information on Airways, and the Adoption of Two-Way Voice Communication Through Radio Telephones

By EDMUND T. ALLEN,[1] OAKLAND, CALIF.

AIR transportation is today passing through the period of change from the somewhat uncontrolled, haphazard stage of travel into the unknown, which characterized the voyages of early sailing vessels, to that other scientific stage which the great railroads are now so fully demonstrating with their block systems, automatic signal and stopping devices, and central control mechanisms.

Safety up to the present time has been achieved largely by the personal skill and wide experience of the pilot. He met each new situation as it arose in the light of mature judgment of weather and his own ability to deal with emergencies, usually with little foreknowledge of conditions ahead. True, he had the usual weather reports and orders before leaving his airport, but once in the air he was practically on his own. The subsequent fogging-in of his course or his terminal was a problem to be solved when he came to it, quite without assistance from the ground.

With the rapid increase of passenger traffic on the San Francisco-New York and coastal air lines, the need for getting on into this new stage of safe, controlled—what we may call "scientific"—air transportation became acute, and it was met with feverish haste by the leading air-line operators.

Radio was declared to be the solution-in-chief.

Uncertainties Formerly Confronting Passenger-Airplane Pilots

An analysis of the uncertainties confronting the pilot in the older stage of air-passenger transport revealed four principal needs:

1. A means for keeping on the course when flying above or in fog
2. A means for effecting a safe landing after having found the terminal in bad weather
3. A means for communicating weather information and orders to the pilot
4. A means for receiving and checking information from the pilot in flight.

The first of these needs, that of navigation, involves finding one's way in bad weather to the terminal airport. When he cannot see the earth or his beacon lights along the airway, the pilot must guide the airplane partially or entirely by the use of his instruments. If he is above fog or, as is sometimes the case, entirely enveloped in fog, he determines his elevation, speed, and the direction in which he is pointed by means of his altimeter, air-speed meter, and compass, respectively. But accurate as all these instruments may be, they do not tell him if he is drifting sidewise in a cross-wind and they do not show how fast he is passing over the ground because of the constantly varying head winds or tail winds. Thus while instrument flying may enable a pilot to keep his airplane at a safe altitude and in a generally correct direction, it does not enable him, without the use of radio, to keep on his course, to determine the location of his terminal airport, or to come down through the fog safely to a landing on the runway.

The radio beacon has now reached a stage of development permitting its use on passenger and mail transports with a high degree of reliability. It solves part of this problem and enables the pilot to keep on his course and fly over the radio-beacon station located at his terminal field. But to alight safely on a small airport by such indirect means is comparable to the problem of bringing the *Leviathan* into New York harbor and docking her in a dense fog—it simply isn't done. The *Leviathan* stops way outside the harbor and drifts at a dead halt until the fog lifts.

Sea navigation with all its intensive development in this scientific age has not yet conquered this phase of its problem. Let us not expect to solve a far more difficult problem easily.

Directive Radio Beacons Now Being Generally Installed

The United States Department of Commerce is now installing directive radio beacons on the principal civil airways throughout the United States, and all transport planes carrying passengers and mail will soon be equipped with beacon receivers.

To use this beacon the pilot has two little soft rubber plugs to which are snapped the tiny microphone receivers of the radio. The plugs fit into his ears and receive the dot-dash of the beacon signal. When he hears a code letter of one kind he knows he is to the right of his true course, and he consequently steers to the left until the signal changes to one long dash. When he goes past to the left, another signal apprizes him of this fact.

A visual receiver has been developed which indicates the pilot's position with respect to the course with small flashing lights or vibrating reeds on the instrument board, but the pilot's preference for the auditory receiver seems to indicate that the visual sense is perhaps already overloaded with duties.

A new type of radio compass appears to have certain advantages over the beacon; it has, however, the disadvantage that the pilot is not informed of his position with reference to the course, but only of his direction. In flying with the beacon in a heavy side wind the airplane remains on the course by flying sideways to the course. With this radio compass the airplane points always toward the terminal, but its flight path describes a curve.

For long-distance flights, radio triangulation determines geo-

[1] Test Pilot and Research Engineer, Boeing Airplane Co. Mr. Allen was educated in the Chicago High Schools, the University of Illinois, and the Massachusetts Institute of Technology. He was an instructor in acrobatic flying in the Army Air Corps during the war, and has been experimental pilot for the National Advisory Committee for Aeronautics, test pilot for Engineering Division of Army Air Corps, air-mail pilot with Post Office Department of the transcontinental route, and pilot of Boeing Air Transport, Inc., Chicago-San Francisco Line.

Presented at a meeting of the San Francisco Section of the A.S.M.E., San Francisco, Calif., January 30, 1930.

metrically the exact location of the airplane on a map, but this is often impractical and unnecessary on a regularly operated air-transport line over land.

The solution of the problem of navigation on a predetermined course is, however, by no means the entire story. One may fly exactly on the proper course, coming to a point directly over the terminal field, and still be in a position of great danger if he attempts to descend through fog to a landing. Let me illustrate with an experience of my own on the Boeing Air Transport Line at Cheyenne, Wyoming. One winter night two years ago, I was forced to land at an emergency field in the desert because of a snowstorm ahead. I telephoned each emergency field for two hundred miles eastward to find the weather conditions and discovered that local snowstorms were scattered all the way east through the entire Rocky Mountain region, with strips of clear weather every thirty or forty miles.

I took off and flew over the top of the first storm, but before I reached the first-reported clear strip the weather had changed and a general blizzard enveloped the entire region. I continued flying eastward, unaware of the fact that the weather had become very dangerous, and hoping to find Cheyenne clear. I had no radio communication, and there were no radio beacons on the route at that time.

Under these conditions, however, a radio beacon without radio communication might have been a great source of danger, for without the information that there was now no ceiling at Cheyenne I should possibly have descended through the fog knowing I was directly over Cheyenne and expecting to be able to see the landing field. As it was it seemed to me too dangerous to come down into unknown weather conditions and over unknown terrain, so I turned back westward and flew until I found a hole in the storm, through which I descended safely and made an emergency landing in the desert.

Broadcasting Weather Information by Radio on Airways

In order to meet just such situations the Department of Commerce is installing a system of broadcasting by radio weather information along the San Francisco-New York and other airways. With the radio-beacon receiver on the airplane the pilot will be able to "listen in" on these intermittent weather reports as they break in on the beacon signal.

Thus we have met and are rapidly solving two of the four problems confronting the pilot, namely, navigation to a point over the terminal, and weather reporting during flight. Two problems remain: (1) safe landing on a fog-bound terminal field, and (2) traffic control, i.e., keeping the ground management in constant touch with the aircraft at all times during flight. The first of these problems we now see no means of solving on a commercial scale, the recent experiments of the Guggenheim Foundation notwithstanding, and we strenuously avoid any possibility of being caught in a position where it is necessary to attempt a landing in fog. Let us remember that all ocean liners also meet their corresponding problem by similar evasion.

The second difficulty is now being attacked successfully by providing two-way radio telephony on the Boeing System on the Chicago-San Francisco and Los Angeles-Seattle mail-express-passenger lines. With the installation of such telephone equipment this nation will have definitely entered upon the new stage of safe, controlled air transportation.

Two-Way Voice Communication a Requisite for Safety

It is not enough for the pilot of an air-mail plane to listen in on beacon signals and on hourly or half-hourly weather broadcasts. For safety, he needs in addition a means of constant voice communication with a responsible official whose sole duties are to see that the pilot has immediately every bit of information he can use in meeting his weather situation. It is not enough for the operator of an air-transport line to be able to read a weather report into the microphone and hope that the pilot somewhere off in the storm has tuned in and is receiving the warning. Constant two-way communication is necessary for safety.

For our purpose of safety and control we must have constant checking of aircraft in the air. The man who is in complete possession of the weather and traffic problems on the ground must know at every minute just where each airplane is, just what its pilot is up against, and just where to direct him for absolutely safe flying and landing, and he must know that the pilot is receiving this information and is acting on the instructions. The pilot will now be in an entirely different situation. Instead of flying into the unknown and meeting shifting weather conditions single handed and without adequate information, he will be maintaining uninterrupted contact with the all-seeing eye of the radio.

He may, for instance, speak into the mouthpiece which unobtrusively rides in front of his lips whichever way he moves his head—"Calling Cheyenne Boeing Station, No. 12 reporting passing Elk Mountain point 106. Fog and snow coming in across course from Medicine Bow range. Fog forming along Union Pacific tracks in Rock River sector. Looks clear to north. Ceiling here 1500 ft., visibility 5 miles. Snow blowing on ground so badly weather station may say zero ceiling and visibility. What is weather in Laramie? Would you advise crossing Sherman Mountains north of the course and coming into Cheyenne from north?"

And instantly comes a reply through his earphones—"Cheyenne Boeing Station talking to eastbound No. 12. Hello, Henry, Laramie has zero ceiling and visibility, local blizzard. Keep to north. Wheatland and Chugwater are clear and Horse Creek has 1000-ft. ceiling. Cheyenne forecast for next hour, fog. We shall send you on to Sidney in case Cheyenne closes in. Are holding westbound because of your information about Medicine Bow. Please answer right away if you have any new conditions; otherwise report on regular five-minute schedule."

Two-way voice communication can also be used to increase the safety of landing under conditions of low ceiling and poor visibility. On one of the occasions when Lindbergh jumped from his air-mail plane near Chicago after attempting to find the Chicago airport through the clouds, the field crew heard his motor overhead and knew that if they could but talk to the pilot and tell him it was safe to come down, he would find himself directly over the landing field. They could have brought him in as easily as a passenger train is threaded through the switching yards to the terminal station.

Operation Automatic

For the pilot the entire operation and mechanism of our new radiophone is automatic. He speaks in a normal voice and listens to the reply without the intervention of a radio operator aboard to give him the messages second-hand. He can easily control the loudness of either the radio-beacon signal or the voice reception as he comes nearer the station, or he can listen to both at the same time, making one or the other louder as he desires. Boeing pilots have received clearly at 200 miles from the control station and at 12,000-ft. altitude, and we are perfecting even greater range.

The effect of this upon the safety of passenger-carrying airplanes will be obvious when one realizes that almost every accident which has occured on the air-transport lines could have been avoided by means of the control which this sort of radio communication will make possible. The era of safe air transportation which is now opening to us is to be attributed to radio more, perhaps, than to any other factor.

The Production of Synthetic Lumber From Cornstalks

By O. R. SWEENEY[1] and ROBLEY WINFREY,[2] AMES, IOWA

O. R. Sweeney

Robley Winfrey

CAREFUL study indicates that most of the big things in engineering development are the result of a previous development in engineering materials. When the engineer was limited to materials that occurred in nature, he could not build complicated machines. With the development of iron and steel, the steam engine, for example, was made possible.

Up until comparatively recent times, the engineer designed his machines and structures to suit materials that were existent, and it is only recently that he specifies a material for his purpose and then seeks to produce a material having the necessary properties. Possibly the best illustration of this materials designing is to be found in the light alloys which were developed especially for aviation purposes.

Possibilities in the Production of Engineering Materials of Enormous Strength

Just how strong, hard, or dense it is possible to make engineering materials is not known at the present time. For example, the astronomer tells us that the indicated density of certain materials on the stars is several tons to the cubic inch. While there is no material on the face of the earth that approaches this density, producing it is not beyond the realms of possibility. Theoretically, the strongest material that could be obtained on the earth with the materials available would be limited by the strength resulting from the attraction of the atoms for each other. The atom is made up of electrons circulating around a dense nucleus which is composed, in most cases, of protons and electrons condensed. Not much information is available to show how strong the core is, but there are reasons to believe that it is much stronger than the atom itself. It is possible to pull an electron out of the atom. We shall know much about the energy necessary to effect this operation when we know the relative orbit of the electron. Atomic nuclei are spontaneously decomposed in certain types of matter on the face of the earth, but no one has yet developed a method of decomposing the nucleus of the atom. It is conceivable that methods will be found which will produce engineering materials of enormous strength by collapsing the atoms or by bringing about certain physical changes within the atom.

At the present time we are limited to the strength of the known things, and no engineering material has been produced which would give the strength that could be expected if the atoms were all in such position that they would effect the maximum attraction for each other.

The strongest engineering material that has been produced to date has a tensile strength of approximately 500,000 lb. per sq. in., but there is no reason for believing that this is the strongest material that can be produced.

The atoms arrange themselves into molecules, molecules arrange themselves into crystals, forming a weaker configuration, because the crystals are usually not attracted to each other as strongly as are the molecules. Then, dispersed through most engineering materials are large quantities of gas, which weaken the material, and there are reasons to believe that cracks or voids filled up with condensed gases or liquids are dispersed through most all materials.

A piece of wood will have a given strength as it occurs in nature. It is possible to comminute this piece of wood in a liquid medium, such as water, into fine fibers, dispersing over them layers of water. This operation is carried out in various types of machines, such as Hollanders and Jordan machines. After the water is thoroughly dispersed over the fibers, they are formed into a mat. The mat is then dried in such a manner as to make as many molecular contacts as possible between the fibers. The resulting material, called paper, is frequently much stronger than the original wood. It owes its strength to the combined molecular contacts and fiber strength.

Paper is, of course, a very old engineering material and is used in a large number of combinations. There is a belief that a paper to be strong must have long fibers. However, it has been shown conclusively in the chemical-engineering laboratories at Iowa State College that the strength of the materials resulting from comminuting the fibers goes up in proportion to the fineness of the material provided the comminution is carried out in such a manner as to prevent the accumulation of air or gases.

Dense, Hard or Tough, Strong Materials From Cornstalk Fibers

By taking corncobs, for example, or cornstalks, cooking them with suitable reagents, such as caustic soda, washing the resulting cooked mass, and then beating the material in a specially designed machine until the fibers are not visible under the microscope, then heating the mass to exclude all possible gas accumulation, a material is obtained which is jelly-like in its properties. By slowly drying this material at low temperatures, a resultant dense, hard mass is obtained having properties superior to such a dense, hard material as teakwood, or such a tough, strong one

[1] Professor and Head of Chemical Engineering Education and Research, Iowa State College. Doctor Sweeney entered upon his present duties in 1920. He received his formal education at Ohio State University, University of Pennsylvania, and in Germany. He taught at the North Dakota State College before the World War and at the University of Cincinnati just prior to going to Iowa State College. During the war he served in the chemical-warfare service at Edgewood Arsenal, Md., attaining the rank of major. Before entering Ohio State University for his undergraduate work he was manager of a steel mill in West Virginia. He gave up this position in order to acquire theoretical knowledge in the field of metallurgy, but after entering college he changed his course to chemistry and chemical engineering. While at Fargo, N. D., he became interested in the utilization of agricultural waste products, the field of his major interest today.

[2] Assistant Director, Engineering Experiment Station, Iowa State College. Mr. Winfrey has been connected with the Engineering Experiment Station since 1922, the year of his graduation in civil engineering from Iowa State College. He edits the engineering research publications and assists in the direction of the research program of the Station.

as lignum-vitae. This material, which has been called "Maizolith," has the following properties:

Compressive strength, lb. per sq. in.	12,000–17,370
Shearing strength, lb. per sq. in.	7,725
Tensile strength, lb. per sq. in.	5,000–10,000
Modulus of rupture, lb. per sq. in.	16,000–38,000
Brinell hardness (of series equivalent to that for brasses and bronzes)	15.2–28.9
Specific gravity	1.3–1.5
Electrical rupture, volts per 0.001 in. thickness	125–200
Water absorption, per cent of original weight in 24 hr.	22–34

In days gone by it was the practice of engineers to choose

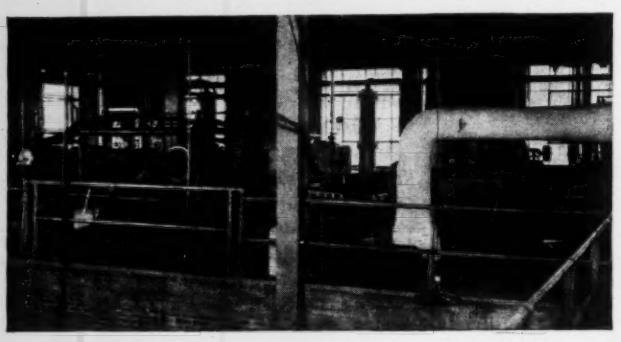


FIG. 1 EQUIPMENT OF SEMI-COMMERCIAL SIZE FOR MAKING INSULATION LUMBER FROM CORNSTALKS, STRAW, ETC.
(Press rolls shown at left; drier at right.)

their wood materials from any natural-grown material available. Teakwood, for example, has to be harvested from jungles in countries far removed from the dense centers of civilization and for that reason it is not generally used. Most of the extremely high-grade hardwoods are imported into the United States and are too costly for use in many places where it would be desirable to use them. However, it would seem, in the light of the work above, that it is possible to produce economically from agricultural wastes a material with most of the desirable properties of the densest and hardest woods.

PROCESS EMPLOYED IN MAKING WOOD SUBSTITUTES

By taking agricultural waste materials, such as cornstalks or straw, hydrating them in proper machines either before or after giving them a cooking with chemicals, it is possible to form them into a mat of suitable thickness and press them into board-like structures. The shape, thickness, and other dimensions of this material can be anything, limited only by the size of mat that can be formed.

After the mat is formed, these materials are simultaneously subjected to hydraulic pressure and heat. By varying the temperature and pressure, wood substitutes of almost any degree of strength and hardness can be produced. For example, by high pressure it is possible to produce a material as hard and as strong as oak, while by lighter pressure, materials the consistency of soft pine can be produced.

The interesting thing about this material is that it is not a difficult matter to produce material accurately to large dimensions and varying in thickness from $1/16$ in. to 2 in. In particular, it is interesting to note that not only a flat board 10 ft. × 20 ft. or larger can be produced, but such things as window sashes and doors can be produced satisfactorily in one pressing operation.

The reactions taking place during the pressing and heating are not clearly understood. It seems, however, that a part of the strength or properties imparted to this material results from polymerization of the pentosan contents of the cornstalks and straw. At any rate, the material resulting is stronger and denser with higher pressure. In appearance and in size it is a highly desirable material for many of the uses to which the architect and engineer usually put wood.

SYNTHETIC LUMBER

A most interesting class of engineering material has come into market recently and is meeting with wide favor among engineers and architects. This material is known generally under such names as synthetic lumber, insulating lumber, artificial lumber, and sometimes wallboard, although this latter term has a well-defined meaning and should not be used.

This material is made in slabs 4 to 8 ft. wide and any length desired, though 12 ft. is as long as it is convenient to handle. At the Dubuque, Iowa, plant of the Maizewood Corporation, this material is produced in slabs 8 ft. wide, 20 ft. long, and $1/2$ in.

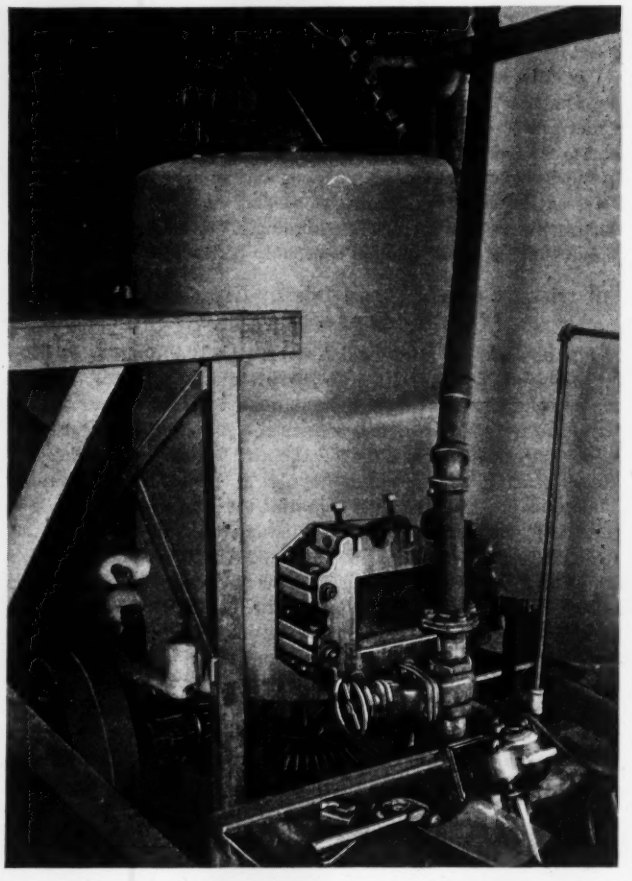


FIG. 2 STEAM COOKER
(Storage tank for pulp and motor agitator shown in foreground.)

thick. It is cut into smaller sizes before marketing, but can be supplied in these dimensions if wanted.

The properties of this lumber are unusual, and there is no material or any vegetable growth in nature which is a fitting substitute for it. Its properties are:

Conductivity, B.t.u. per sq. ft. per deg. fahr. per hr. for 1 in. thickness	0.32 to 0.34
Modulus of rupture, lb. per sq. in.	300 to 800
Weight, lb. per 1000 sq. ft. ($1/2$ in. thick)	600 to 750
Tensile strength, lb. per sq. in.	200 to 250
Nail-holding power, lb. (4 six-penny nails)	250 to 300
Plaster bond, lb. per sq. ft.	1200 to 2000

SUBSTITUTE FOR BALSA WOOD

While this material does not approach wood in strength, because of its large size and method of application it has been found to give stronger structures in most cases than ordinary shiplap. The waste in this material is very small compared to that in commercial lumber. The labor of applying it is much less, and at its present market price it is found to be a cheaper building material than shiplap and paper. This, however, is only one of its uses. It is finding wide employment in nearly every industry. Several million feet a day are being marketed at the present time, and the demand for it is rapidly increasing. When properly fabricated, it is probably the best, practical acoustic material available. Among the very light woods on the market at the present time is balsa wood, which is indispensable in a number of industries. Balsa wood, however, comes from comparatively small trees and the pieces are so small that the glues used in fabricating them into structures of any size usually greatly reduce the properties of the wood itself, increasing its weight and decreasing its conductivity and its insulating properties. It is possible, by properly hydrating cornstalks or other agricultural wastes, and by applying proper pressure, to produce a material of greater strength, of the same density, and with practically the same properties as balsa wood. The interesting thing about this operation is that the pieces can be made in almost any size that may be desired.

ACOUSTIC BOARD MADE FROM CORNSTALK PITH

One of the lightest vegetable materials that occurs in nature is the pith of the maize plant. Devices have been perfected which enable a separation of the pith from the rest of the corn plant to be carried out economically. The pith can be pressed into blocks after a mild hydration, care being used not to break up the air cells to any large extent. The resulting material when dried between steam-heated press plates is of unusual lightness, having a density of 3 to $3\frac{1}{2}$ lb. per cu. ft. The acoustic properties of this material are unusually high, the conductivity low. Particular boards have been made with a conductivity of 0.24 B.t.u. per hour per degree fahrenheit per inch of thickness. When it is remembered that the conductivity of air is only 0.20, it can be realized how nearly perfect this material is as an insulator. The blocks as produced are very weak in strength. However, they are strong enough to enable them to be handled by careful workmen, and it would seem that there is a very decided market for this material.

In particular, the great hardships which the aviator has to suffer could be greatly reduced if his cabin were lined with this splendid acoustic material. Likewise, due to its high insulating value, it would make the cabin warmer or colder, depending on whether the heat was coming in or going out. It would be particularly valuable to the airplane and other industries where low-density material is needed.

CORK SUBSTITUTE

The matter of cork is of great concern to the engineer. In North America, cork is one of the most widely used engineering materials. It is used for insulation, gaskets, floats, and many other articles. The entire cork supply of the world comes from a tiny strip of land in southern Spain, and from a few artificial plantations in Morocco. Being a very light material it is difficult to transport economically, and being the irregular bark of a tree, having a large number of worm holes and imperfections, it is anything but ideal for the uses to which it is put. Cork is not a highly cellulosic material, but contains a large proportion of fatty acids of various kinds. In this respect it is quite different from wood. While it is not yet possible to make a substitute for cork in all its uses, studies made in the chemical-engineering laboratories at Iowa State College indicate that for almost all of the individual uses of cork, a material can be produced which would be equal or superior to cork for that particular use. Insulating materials for making bottle stoppers, or "corks," have been found which are perhaps better in each detail, with the possible exception of waterproofing, and it is believed that this part

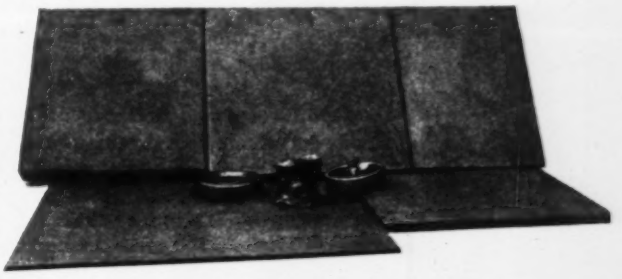


FIG. 3 MATERIAL MADE FROM CORNSTALKS

(The board at the upper left is made from pith; the one in front at the left is a very hard and dense board which has been pressed out between steam-heated plates. The three small pieces in the center are made from finely ground stalks. The one in the middle is a block of maizolith as formed by the drying process; the other two pieces are blocks that have been machined to shape.)

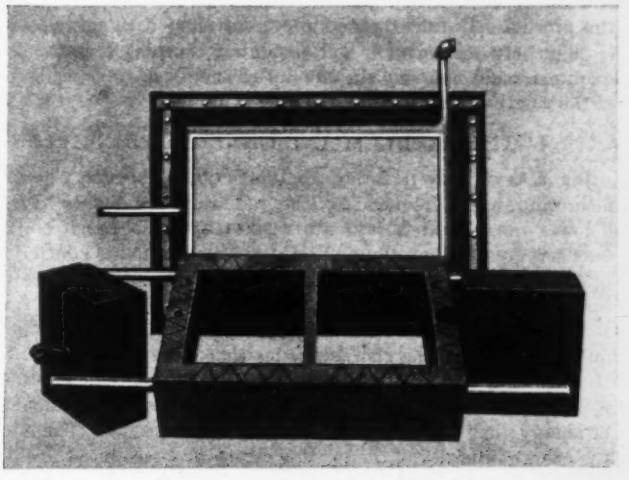


FIG. 4 EXPERIMENTAL MOLD USED AT IOWA STATE COLLEGE FOR PRESSING OUT WINDOW FRAMES FROM CORNSTALK PULP

of the problem will be solved. It is possible to produce better insulating material than cork from waste materials, and it is not unlikely that in the near future large, uniform blocks of materials will be produced which will displace cork in most of its present uses.

It therefore seems that in the progress of civilization throughout the centuries the substitution of annually grown crops for perennial crops has always been attended with rapid development in civilization. When primitive men ceased to glean from the forests and the fields their livelihood, depending as they did mainly upon perennial growths, and began to plant annual crops such as wheat, maize, and barley, life became more certain and economic progress greater. The one great and important raw material today which still remains perennial in its source, is wood. In the light of the present work, it would seem that many of the materials which at the present time come from the forest can be synthesized from annually grown crops, from which paper and engineering materials, designed to suit the individual needs of the inventor, can be made available in any quantity and in almost any specified size.

Combustion Radiation and the Planck Quantum Theory

By WALTER J. WOHLENBERG,[1] NEW HAVEN, CONN.

THE quantum of energy emitted in radiation is represented by the simple formula $h\nu$. In this, h is Planck's constant of action, a universal constant having a single numerical value no matter what may be the source of the emission. The symbol ν denotes the frequency in oscillations per second of the radiated wave. The frequency of the quantum thus establishes the amount of its energy, regardless of the source from which it was radiated. Conversely, the maximum frequency possible for a quantum of energy is fixed simply by the energy which may be available, also independently of the source of this energy. Quanta are indivisible. They must be emitted and absorbed as whole quanta. Fractions are not tolerated in this process. During their journey, traveling with the velocity of light between emission and absorption, nothing is lost. The quanta remain uniquely the amount of energy $h\nu$, independently of the length of this journey.

I—THE PROBLEM AND GENERAL PRINCIPLES

Light, as we know it, is the radiation of quanta of energy having a certain range of frequencies, heat radiations are quanta having a lower range, and X-rays are quanta within a range of frequencies greater than those of light. All radiation is emitted in quanta, whatever may be the frequency. The result of the radiation, which we recognize as light, heat, X-rays, or other forms, is thus fixed entirely by the frequency of the quanta. These quanta determine the characteristics that must be possessed by the elements that are to absorb them. But the frequency that it is possible for emitted quanta to possess is fixed by the amount of energy that can be transformed into a quantum. Therefore the energy intensity of the sending elements determines the characteristics which will be possessed by the radiations.

Any attempt to picture the essence of the quantum beyond the pure energy conception of it results certainly in a severe strain on the imagination and is fruitless. For example, the quantum may be emitted and absorbed within an atom. On the other hand, during its journey from atom to atom, a single quantum may spread itself over a 100-inch mirror.[2] The instant that it strikes an absorbing atom the entire quantum passes into this atom and does so without any disturbance to any other quanta that may be in transit at the same instant in the same space-time element. Eddington[3] has said:

> We must not think about space and time in connection with an individual quantum; and the extension of a quantum in space has no real meaning. To apply these conceptions to a single quantum is like reading the Riot Act to one man. A single quantum has not traveled 50 billion miles from Sirius; it has not been 8 years on the way. But when enough quanta are gathered to form a quorum there will be found among them *statistical properties* which are the genesis of the 50 billion miles' distance of Sirius and the 8 years' journey of the light.

Since the quantum of energy is fixed in magnitude simply by the product $h\nu$ and independently of the source of the radiation and requires for its emission or absorption something which in behavior characteristics simulates, within the atom, some sort of oscillator, Planck, in his analytical treatment of the problem, begins by considering a group of simple harmonic oscillators of all frequencies placed within the so-called "hohlraum." Inasmuch as Planck does not deal specifically with the radiation which may be emitted at space-time elements where atom groups are reacting to form product molecules, questions may arise in the minds of those not familiar with the later developments in radiation concerning the nature of such radiation. It is obvious, however, from the preceding discussion that whatever doubt exists is concerned only with the frequency ranges within which the energy of this radiation may be distributed.

The developments of Dirac, Fermi, and Einstein deal with the interaction of radiation involving any system of molecules, but with these the engineer is only rarely familiar. Nor have these developments, to the author's knowledge, ever been applied by the mathematical physicist to evaluate energy distributions over radiation frequencies resulting from the reactions of the particular kinds of groups of atoms involved in the atmosphere of the usual combustion processes. Perhaps for such reason engineers have sometimes considered the radiation emitted at space-time elements where atom groups are reacting to form product molecules as something of a specialty. In particular it has been assumed[4] that such radiation quanta are unusually large and behave in a peculiar way. The questions which this point of view forces on us are important. Certainly if such a state of affairs actually existed we could place no confidence in the conclusions reached by means of the Planck theory when applied to conditions in which combustion radiation plays a considerable part.

It is conceivable that the method of Dirac could be employed directly in an attempt to answer this question and that this would require no approximations, although the mathematics involved would probably be extremely complex. Fortunately, however, an application of the law of the distribution of energy as developed in statistical mechanics leads, within stated limits of error, to the same solution. These limits are within those permissible for the purpose of this discussion and accordingly this paper attempts this method of attack. The law of the distribution of energy is based on the first and second laws of thermodynamics, and in the course of developing it, the partition of energy on the quantum principle must be introduced. The application of the second law to this problem is so important that the general discussion of the law with reference to this problem in particular must first be undertaken.

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[2] "The Nature of the Physical World," by A. S. Eddington, chap. 10.

[3] Ibid.

ACKNOWLEDGMENT: The author wishes to express his indebtedness to Mr. Martin A. Mayers for suggestions made and assistance in preparing this paper.

[4] N. Artsay, "Analysis of Heat Absorption in Boilers and Superheaters," Trans. A.S.M.E., vol. 51 (1929), paper no. FSP-51-37.

APPLICATION OF SECOND LAW OF THERMODYNAMICS

The special feature of the second law of thermodynamics—that it specifies the direction of an energy process independently of the nature of the involved microscopical processes which enter to form, in their aggregate effects, the whole effect—provides the chief point of attack. From this aspect it is not essential to have a complete knowledge of the exact details of the individuals composing a crowd in order to judge the behavior of the crowd as a whole; and so, as Eddington says, we have no hesitation in applying the second law to problems of the quantum theory although the mechanism of the individual quantum process is unknown and at present unimaginable. We are concerned with properties of the crowd rather than those of the individual.

Entropy is a property of the crowd. It is an indication of the macroscopic state of the energy of the system as distinguished from the microscopic state of the energy. There are many complexions of a group of microscopic particles which are indistinguishable from one another when viewing the energy macroscopically. In this problem we are interested in the macroscopic effects of the radiation which may be emitted at the space-time elements where atom groups are reacting to form product molecules. It does not concern us that some particular few of such atom groups may have peculiar behavior characteristics. For these the fraction of the total energy involved is so small that its macroscopic effects are too minute to be discovered with instruments hundreds of times more accurate than the best available to the physicist today.

Since the macroscopic effects are really the result of the activities of the billions of microscopic particles which are involved and because definite behavior characteristics may not be assigned to individual particles, it becomes necessary to introduce the probability that a particle will behave in a certain way. The greater the probability of a certain behavior, the larger will be the number of particles which behave in this way, and so, where billions of particles are involved, the fractional parts of the total number of particles and hence of the total energy are correct within a negligible error. Thus, as a necessary part of the investigation, we shall later find what the energy distribution is among a group of particles which are in thermal equilibrium with one another.

The foregoing statement brings to mind the fact that there are intervals during a reaction when the speed or apparent disorder are so great that we are unable to follow successive states in detail and therefore use the words "not in equilibrium" as roughly descriptive of the macroscopic changes involved. However, the dictates of the law hold even in the interim between so-called equilibrium states. If this were not so, the resultant equilibrium states which we are able to measure would not correspond with the results of computations in which no assumptions concerning the mechanism of the process have been made but which are based on the law. However, these results do so correspond. It follows, therefore, that any assumed state of the reaction which is to represent conditions that might have existed in the interim in which the rate of progress is beyond experimental determination, but which makes it necessary to violate the law in order to get from the assumed to the known state, is a figment of the imagination having no basis in reality, and hence could not have existed. By this means it is possible to test the various assumptions concerning the energy states during the reaction, and so by trial and error, if in no other way, all modes of procedure which are not consistent with the second law of thermodynamics may be eliminated.

OUTLINE OF SECTIONS OF PAPER TO FOLLOW

It is apparent at this stage that no preconceived notions of the distribution of the radiated energy in units of large or small quanta have been established. This question is considered with reference to the two end states of the reacting groups of atoms in the second and third parts of the paper. The fourth part deals with the possible ways in which radiation energy may momentarily be distributed between the beginning and end of the reaction. The fifth part deals briefly with the Planck quantum theory as it must, in the light of the foregoing, be applied to evaluate the radiation from a system involving combustion. In the sixth part the radiation problem of the boiler furnace is taken up in its most general aspects.

II—RADIATION ENERGY DISTRIBUTION AS JUDGED FROM THE END STATES OF THE REACTION

Fig. 1 shows the distribution of energy in the normal radiation spectrum. The curves show the relation which exists between frequency and the energy intensity per unit volume with which the source of radiation, i.e., the vibrations of the oscillators, is in equilibrium. This relation is shown for three temperature conditions, 1000, 5000, and 10,000 deg. cent. absolute. The curves are based on data obtained by means of the Planck radiation formula.

It will be noticed that even for very high temperatures the maximum frequency for which any appreciable part of the energy is involved is of the order of 10^{15}. If, then, practically all of the energy which is radiated by the atom groups that enter into combustion to form product molecules is to come within this spectrum, the quanta, in units of which it is emitted, may have frequencies no higher than those for all but a negligible part of the total of this energy. But the frequency, as before noted, fixes the energy per quantum.

Let

$$H = h\nu$$

where H represents the energy of the quantum $h\nu$. If for any group of atoms which enter a reaction to form a product molecule the total released energy is transformed into a single quantum of radiated energy, then we should have the quantum of maximum energy and hence the frequency possible for the process.

This would not be true if the reaction should occur instantaneously in space-time with a collision between the reacting group and another molecule. This condition, however, amounts to an instantaneous three-atom or three-molecule collision in space-time, and the probability of such an event is so small that its effect is neglected even in the more rigorous theories of statistical mechanics. A collision of two atoms or molecules followed, if by even the smallest instant, by that with a third could not emit this larger quantum. The energy change of the succeeding collision would result, if in radiation, in a second quantum. The probability of the three-molecule instantaneous collision in space-time is of the order of 10^{-9} as compared to that of the two-molecule or two-atom collisions. This means that roughly only the one-billionth part of the quanta emitted could be generated under these conditions. Furthermore, from the energy considerations involved, it may be shown that on the average even such few of these quanta as may be emitted cannot possess an energy content per quantum which is, for instance, ten times that contained in the average of the two-atom collision when both sets of collisions occur within a zone of the same energy intensity. Thus it is obvious that no measurable amount of the radiation could possibly be emitted from such a source as the three-particle collisions in space-time points. The total energy involved in instantaneous collision of more than three particles is, of course, very small, even in comparison to that involved in three-particle collision.

AVERAGE ENERGY RELEASED PER PRODUCT MOLECULE

Consider the energy of combustion of a fuel as determined in

the calorimeter. As this is the energy released in the combustion of a given weight of the fuel, it is possible to determine, as a first approximation, an average of the part released by the formation of each molecule resulting from the reaction. We shall now proceed immediately to an evaluation of this average but with the fact in mind that it is but a first approximation. Later, the energy release per product molecule will be investigated more closely in order to discover what fractions of the total released energy may have been contributed in release quota per product molecule, which may differ considerably from the average.

Let E_A represent the energy, including the chemical energy, per unit fuel weight of the mixture in the bomb calorimeter before the reaction takes place, and E_B the energy of the resulting products and mixture after the reaction has occurred and the temperature has been returned to its initial state. The energy

$$\Delta E = E_A - E_B$$

which has left the system is the heat of combustion and represents the difference in the energies of the mixture in the initial and final states. Thus when we write the equation

$$C + O_2 = CO_2; \quad \Delta E = -14{,}600 \text{ B.t.u.},$$

we mean that at a given temperature, 14,600 B.t.u. are evolved when one pound of carbon has combined with oxygen to form 3.67 pounds of CO_2. This represents the total energy that can be radiated from all of the CO_2 molecules formed in the combustion reaction. This is true when the product CO_2 has been reduced to the temperature at which the reaction started. Therefore, as long as the temperature of the CO_2 is above that at which the reaction started, some of the ΔE will be retained as increased thermal capacity of the products and hence is not available for net radiation to the furnace walls. Since the combustion gases in a boiler furnace always escape at a temperature considerably above that at which they enter, only a fraction of ΔE is absorbed at the furnace walls by radiation. This fraction may vary roughly from one-fourth to one-half.

Let Δe represent the average energy released per molecule of product formed in the reaction and let N represent the number of molecules formed per pound of fuel burned. Thus the relation

$$\Delta e = \Delta E/N \ldots\ldots\ldots\ldots\ldots\ldots [1]$$

represents, purely on the basis of the first law of thermodynamics, the mean value of the maximum possible energy per quantum of radiation and does not as yet take into account what the second law may prescribe for the way in which, in a macroscopic sense, the quotas Δe must be divided into quanta.

Consider first the combustion of carbon to carbon dioxide. The figures are as follows:

Calorific value, B.t.u. per lb. = 14,600
Calories per gram = 8090
Molecular weight = 12
Loschmidt's constant, number of molecules per gram-molecule = 6.06×10^{23}

$$\text{Number of molecules per gram} = \frac{6.06 \times 10^{23}}{12} = 5.05 \times 10^{22}$$

Ergs per gram-calorie = 4.187×10^{7}
Calorific value in ergs per molecule for reaction of C to CO_2,

$$\Delta e = \frac{8.090 \times 10^{3} \times 4.187 \times 10^{7}}{5.05 \times 10^{22}}$$

$$= 6.71 \times 10^{-12}$$

Frequency of the theoretical quantum of energy $\Delta e = H = h\nu$ considered as emitted in a single discharge in the combustion of C to CO_2;

$$\nu = \frac{6.71 \times 10^{-12}}{h} = \frac{6.71 \times 10^{-12}}{6.53 \times 10^{-27}} = 1.211 \times 10^{15}$$

By a similar set of calculations the following information is obtainable concerning the maximum frequency of emission during the combustion of the other constituents shown:

CO to CO_2 { $\Delta e = 4.73 \times 10^{-12}$ ergs; $\nu = 7.26 \times 10^{14}$

H_2 to H_2O { $\Delta e = 4.76 \times 10^{-12}$ ergs; $\nu = 7.28 \times 10^{14}$

By the same method of computation it may be shown that a reaction between oxygen and any combination of the above fuel constituents will yield average quota Δe of the order of magnitude shown or smaller.

The frequency values just shown represent the maximum possible in the average energy release per product molecule. It is seen that they fall near the outer or high-frequency border of the infra-red spectrum. This is just what we should expect because, as will be shown by reference to the second law, the conditions under which such quanta are assumed to be emitted are, in a macroscopic sense, the least probable of all the conditions under which emission in reaction may take place. This is exactly what

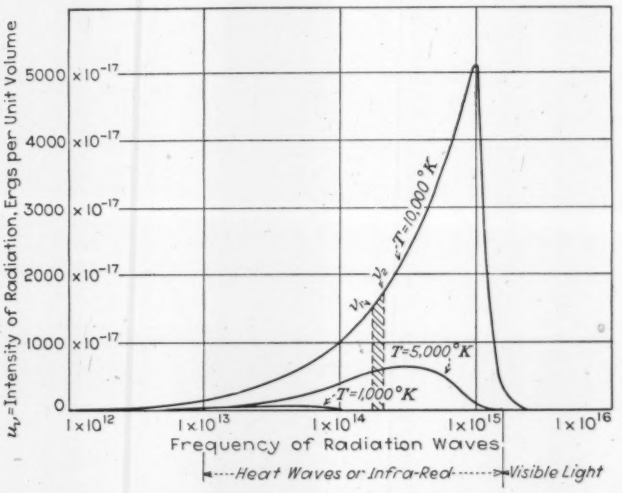

FIG. 1 INTENSITY OF RADIATION FROM A BLOCK-BODY OSCILLATOR AT VARIOUS TEMPERATURES

is shown by the distribution curves of Fig. 1. The ordinates of these curves represent to some scale the probability of the emission of quanta of the frequencies shown by the abscissas, but for black-body radiation. Under these conditions, oscillators capable of sending out all frequencies were assumed to be present. Two questions now arise. First, what does the second law of thermodynamics tell about the probability that a quota Δe will be converted into a single quantum of energy? Second, what does the same law tell about the part of the total energy released which may emerge in quota Δe which are large or small as compared to the average values found in the above computations? It is apparent from the foregoing discussion that the answers to these questions will furnish all of the information required to determine the characteristics of the radiation for all but a negligible fraction of the total energy evolved. The answer to these questions involves, of course, a knowledge of the energy distribution. This subject is discussed in the following section of this paper.

(*To be continued*)

Survey of Engineering Progress

A Review of Attainment in Mechanical Engineering and Related Fields

CORROSION

The Influence of Stress Range and Cycle Frequency on Corrosion

AFTER a brief résumé of previous work and a description of methods of investigation, the author proceeds to the discussion of the influence of the cyclic stress on corrosion as illustrated by Type-5 diagrams. (In those diagrams abscissas represent corrosion times and ordinates represent fatigue limits of the previously corroded specimens.) Stressless corrosion, total damage, and net damage are illustrated, and methods are given for deriving other diagrams to illustrate the influence of stress range and cyclic frequency on corrosion. The influence of stress range and cyclic frequency on corrosion of steels, aluminum alloys, and monel metal is discussed.

The field of investigation has been extended to include the influence of nominal stresses far above the endurance limit and even above the tensile strength. Influence of cycle frequency is illustrated by constant net-damage diagrams, Type 10. This is a constant-stress graph representing the relationship between the total number of cycles and the time necessary to cause constant net damage. A Type-10 graph also represents the relationship between cycle frequency and the time necessary to cause constant net damage, however, varies inversely as the average rate of net damage. A Type-10 diagram therefore throws some light on the influence of cyclic frequency on the average rate of net damage, throughout a total of 15 per cent net damage. The graphs for steels are nearly straight and nearly parallel lines, while the graphs for duralumin and monel metal are not quite straight and hence not parallel. The influence of stress range and cycle frequency on the rate of net damage is discussed. It is found that total damage may proceed at a continually increasing rate or it may proceed first at a decreasing and then at an increasing rate. Net damage for all metals, however, probably proceeds at a continually increasing rate. Relationship between corrosion stress and the initial rate of net damage is of a logarithmic straight-line type, and the original paper gives equations representing this relationship. The initial rate of net damage varies as a power of the corrosion stress, the power exponent varying with the metal and probably with the corrosion conditions.

The influence of cyclic stress on net damage is evidently due largely to the influence of the cyclic deformation of the surface-film and corrosion products. By "film" is here meant the entire primary layer that is affected by contact with the corrosive medium. That there is no distinct surface of demarcation between the film and underlying metal has been shown by the work of Prof. U. R. Evans and others. The oxygen or other negative element penetrates to some extent the space lattice of the metal. The word "film" as here used applies not only to the oxide layer but also to the underlying layer of metal into which oxygen or other negative element has penetrated. By "corrosion products" is here meant the secondary compounds, such as rust, that are precipitated on the surface of the metal. The film and corrosion products together are designated as the "coating."

Stressless corrosion involves diffusion of the negative ions inward and diffusion of the metal ions outward through the film. Corrodibility of a metal depends not only on the inherent solution pressure, but also largely on the permeability or "porosity" of the film. The resistance of stainless steel, for example, to fatigue-corrosion as well as to stressless corrosion is greater than the resistance of ordinary steels because the surface film of stainless steel is less permeable than the film of ordinary steels. Investigation by Speller, McCorkle, and Mumma has thrown much light on the subject of the influence of the surface film on corrosion fatigue.

The evidence of the influence of stress and cycle frequency presented in the present paper suggests the following tentative ideas about the influence of cyclic stress on corrosion. These ideas are subject to change as additional evidence accumulates.

Stress increases the corrosion rate by increasing the permeability or effective "porosity" of the coating. If the applied stress remains steady, most of this increase in equivalent porosity is only temporary. There is temporarily increased diffusion of ions in both directions through the coating. This soon results in repair of the enlarged "pores" and the diffusion falls to the normal rate. If the stress is cyclic, however, there is in each cycle a temporary increase in porosity, resulting in temporarily increased rate of diffusion. The greater the stress range, the greater is this cyclic increase in porosity, and hence the greater is the rate of net damage.

Corrodibility of a metal, however, depends not only on the permeability of the coating, but also on the inherent solution pressure of the metal. Corrodibility of some metals, such as copper, is slight, chiefly because of the low solution pressure. U. R. Evans says the surface film of copper is weakly protective. For many other metals also, corrosion resistance depends rather on low solution pressure than on the protective effect of the films.

The influence of cyclic stress on corrosion, therefore, may not be due entirely to cyclic distortion of the coating. The influence of cyclic stress, especially when the stress range is high, may be due partly to cyclic cold working of the metal. Cyclic cold working possibly increases the solution pressure. The effect on the solution pressure would probably be relatively greater for alloys of low inherent solution pressure than for alloys of high solution pressure.

Type-10 diagrams of the first class all represent alloys having relatively high inherent solution pressure. Their resistance to corrosion depends chiefly on the protection afforded by the coating. The Type-10 diagram of the second class represents an alloy having relatively low inherent solution pressure. Additional information is needed to determine whether or not there is a general relationship between the form of the Type-10 graph and the solution pressure of the alloy. Further discussion of this subject, moreover, must be deferred on account of lack of space.

The net damage is the total damage due to fatigue corrosion less the damage that would be caused in the same time by stressless corrosion. A brief bibliography of the subject is appended. (D. J. McAdam, Jr., Metallurgist, U. S. Naval Engineering Experiment Station, paper before the Annual Meeting of the American Society for Testing Materials, Atlantic City, June, 1930, abstracted from a mimeographed preprint, *e*)

ENGINEERING MATERIALS

Chromium-Copper Structural Steels

THE good qualities of high-silicon steels are well known. It is also known that the manufacture of sections of high-silicon content is difficult. It seems, however, that in Germany a structural steel has been developed which possesses none of the disadvantages usually associated with high-silicon steel. This material has the following approximate composition: Carbon, 0.15 to 0.18; silicon, 0.28; manganese, 0.8; chromium, 0.4; and copper, 0.55 to 0.8 per cent.

Tests were made to determine the effect of composition on the steel. Steels containing chromium in addition to manganese do not offer any advantage for structural purposes over the usual type of steel containing high manganese only. The addition of from 0.5 per cent to 1.2 per cent of copper to steels containing up to 1 per cent of chromium leads to a marked improvement in the properties. In addition to their improved resistance to atmospheric corrosion, steels containing about 1 per cent of copper offer the further advantage that they are less sensitive to variations in the rate of cooling after normalizing. Within the range of composition investigated, the best properties were obtained in a steel containing 0.3 per cent of carbon, 0.5 per cent of manganese, 0.9 per cent of chromium, and 1.2 per cent of copper. The mechanical properties of this steel compare favorably with those of the best manganese-silicon structural steels, and are better than those obtainable in structural steels containing high manganese only. (J. A. Jones, in a communication from the Research Department, Woolwich, read before The Iron and Steel Institute, London, May 2, 1930; abstracted through *Engineering*, vol. 129, no. 3358, May 23, 1930, pp. 687, 2 figs., *dp*)

Linatex Rubber

IN THE November, 1929, issue of MECHANICAL ENGINEERING, Vol. 51, No. 11, p. 852, an abstract from the *South African Mining and Engineering Journal* of August 10, 1929, was published dealing with the so-called linatex rubber. In that article it was stated that the exact method of manufacturing this rubber was not mentioned.

Since then there has become available a catalog issued by the Wilkinson Process Rubber Sales Corp., Chicago, Ill. While this catalog does not give complete information it tells a little more than the previous publication. It appears now that in the Wilkinson process ("linatex" is the trade name of the product), fresh rubber latex is used. This latex is adjusted chemically so that nascent sulphur is released from a sulphur containing protein present in the latex. A small amount of chemical matter is added together with a coloring pigment, but these are not added in powder form, the chemical being broken down in special machines on a film of water into a very fine state of subdivision so that a colloidal or pseudo-colloidal state results. Only a mild agitation or stirring is necessary, the rubber being in liquid form. A state of what may be termed incipient vulcanization is produced and no heat is used in the process.

At the conclusion of a period of standing, the chemically treated and activated latex coagulates and the coagulum is carefully machined at once into standard crepe of unit width and thickness. The wet crepe is then dried for an average period of seven days. At the conclusion of this period and after laboratory control, the crepe is wound on bamboo spools and taken to the "building-up" department. Here the spools are fitted on spindles at the end of wooden tables 50 ft. long by 5 ft. wide. A length of crepe is pulled off the spools the full length of the table and cut off. Then another length is pulled off the spool and superimposed on the first length. By cutting the two pieces of crepe lengthwise along the edge a joint is effected when the length of crepe is opened bookwise, thus doubling the width. This joined length is moved out a little from the operators and another length of crepe superimposed as before from the spools. This is cut as already described and eventually a piece of single crepe 50 ft. long by 5 ft. wide is produced.

At the other end of the table is a larger spool upon which are wound these larger sheets of crepe. When full, these larger spools are removed to a rubber-covered table of dimensions similar to those of the cutting table. Here the single sheets of crepe are pulled off the spools and patted down flat on the rubber cover of the table. Layer after layer is added, care being taken that the joints in the crepe are not coincident. According to the thickness desired, a predetermined number of layers is used.

From this table the hand-laminated sheet is fed into a powerful even-geared smooth-roller machine which is electrically driven and reversible. The sheet passes to and fro between the rolls of the machine which are gradually tightened during the process, and the result is a sheet of "linatex" of homogeneous structure.

To prevent elongation and to increase tensile strength, a special form of fabric is sometimes introduced in the construction of the sheet. This fabric is woven from pure long-stable cotton of great length and before inclusion is proofed at atmospheric temperature by the specially treated latex before the latter has coagulated. As this fabric is never heated, it retains all of its original strength. (From a catalog entitled, "Linatex," issued by the Wilkinson Process Rubber Sales Corp., 53 W. Jackson Blvd., Chicago, Ill., *d*)

FOUNDRY

Centrifugally Cast Alloy-Steel Guns

AT PRESENT some of the smaller guns are being cast centrifugally of molybdenum steel containing 0.35 to 0.40 per cent carbon and about 0.40 per cent molybdenum, with occasionally an addition of a small percentage of vanadium. The steel is melted in an Ajax-Northrop high-frequency furnace and poured into the rapidly revolving mold at regulated speeds and temperatures directly from the furnace. Removed from the machine at a heat above its recalescence, the piece is properly heat treated.

The carbon content of the inner bore is higher than that of the outside of the piece, a condition especially desirable and easily recognized by ordnance men. The impurities collect on the inside of the hollow casting and are easily removed.

The next step is to give it the hydraulic cold-working treatment. The casting is placed in a special container or metal jacket, and is then subjected to a hydraulic pressure up to 120,000 lb. per sq. in. so that the bore is increased by 6 per cent, while the outside diameter by only a small amount (about 0.80 in.). By a suitable heat treatment after this hydraulic cold working, the elastic limit is increased.

The advantages of this development are first that it is possible to make three guns by casting in the time that it takes to make one by forging. The excessive machining and boring necessary on forgings is largely eliminated and the physical properties of the product are superior.

Gun carriages of several types are produced by welding, thus eliminating the cumbersome and heavy cast-steel carriages.

The art has been so perfected that the army can now be supplied with light apparatus that is not only reliable in supporting guns in action, but is easily transportable over wide territory. By suitable structures, guns can be transported on commercial trucks to almost any desired location. A welded tractor equipment has been developed which, applied to the six wheels of a truck, makes it possible to negotiate the most difficult terrain. The caterpillar equipment is so simple and yet so light that it can

be removed or put on any large commercial truck. With the new welded supports or carriages, guns of various sizes and types are ready for immediate action in almost any locality. (Maj.-Gen. T. C. Dickson, Commander, Watertown Arsenal, Watertown, Mass., before the Cleveland Engineering Society, May 13, 1930, abstracted through *The Iron Age*, vol. 125, no. 21, May 22, 1930, pp. 1521–1522, 1 fig., *d*)

HYDRAULIC ENGINEERING

Graphs for Rapid Determination of Principal Dimensions of Hydraulic-Turbine Wheels

THE logarithmic graphs shown in Fig. 1 are intended for the rapid solution of the following problems.

(1) Formula for specific velocity

$$N_s = \frac{NP^{0.5}}{H^{1.25}}$$

in which N_s is the specific velocity in r.p.m., i.e. the velocity of a turbine similar to the one being studied which would produce 1 hp. output for a head of 1 m. (3.28 ft.)

(2) Formula giving a ratio of similarity between the turbine under investigation and a turbine producing 1 hp. for one meter of head.

$$m = \frac{P^{0.5}}{H^{0.75}}$$

The following process is used in order to determine rapidly the main dimensions of a turbine providing the following are known; output in horsepower P; speed of rotation N in r.p.m.; height of fall H in meters.

(*a*) Determine first the specific velocity N_s from the given values of N, P, and H by means of the nomogram on the left of Fig. 1 following the method indicated by the arrows for the given example ($N = 300$; $P = 1000$; $H = 33$).

(*b*) The ratio of similarity m is determined from given values of H and P by means of the nomogram on the right of Fig. 1 following the sequence indicated by the arrows.

(*c*) The dimensions of the turbine are obtained by multiplying by m the dimensions of the turbine of velocity N_s delivering 1 hp. at a head of 1 m. If the designer does not know the dimensions of his typical turbine (1 hp. for 1 m. head), results suitable for a preliminary design can be obtained by using the values given on the scales located to the left of the scale of the values of N_s. These scales d_1, d_2, l, and d have been plotted on the basis of a table given by P. Cayére in *Arts et Métiers*, Aug., 1925, p. 325. The results obtained from the above tables are applicable only to turbines with fixed blades as turbines with variable blades have

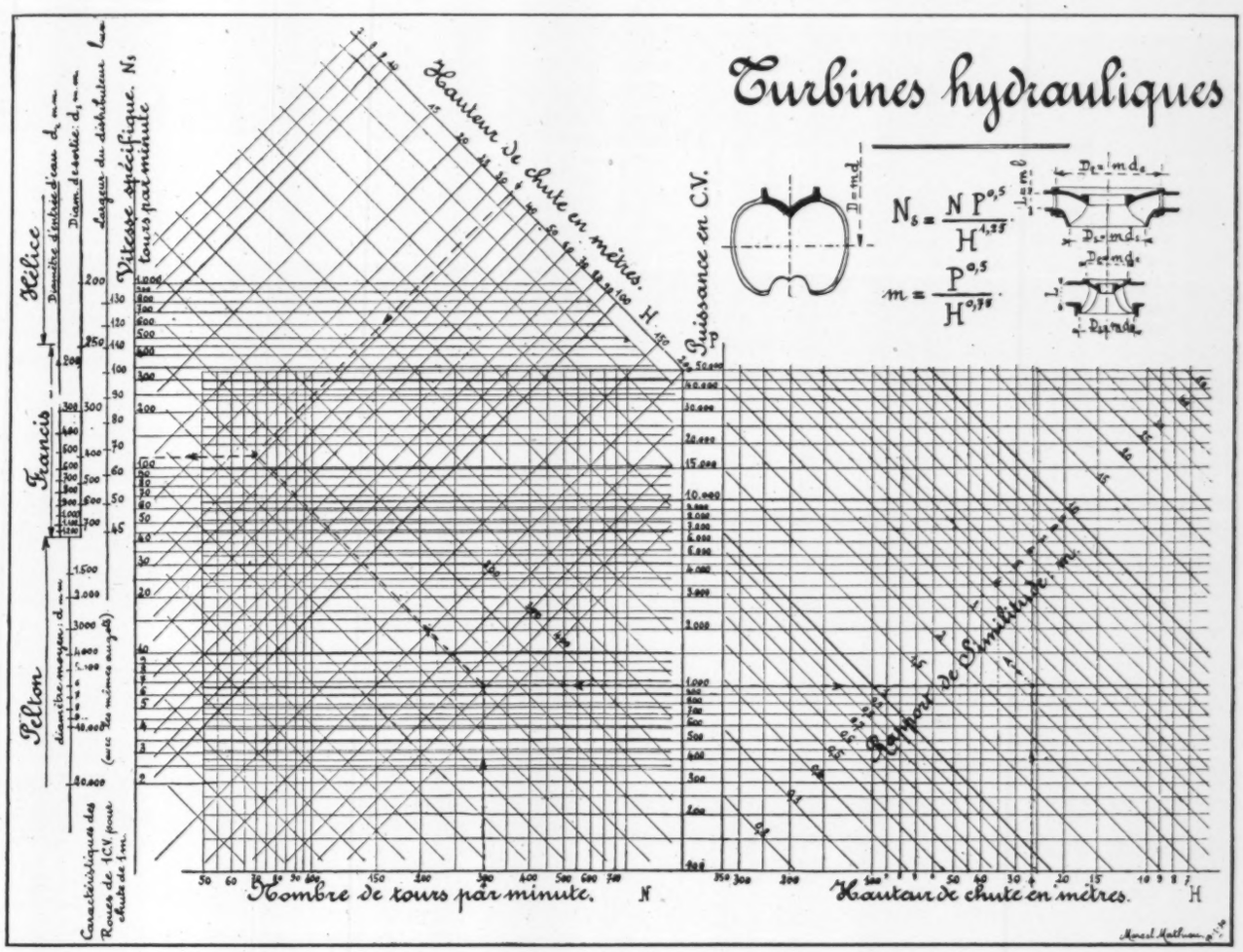

FIG. 1 HYDRAULIC TURBINES

(Hauteur de chute en metres = head in meters; rapport de similitude m = ratio of similarity m; nombre de tours par minute = r.p.m.; diametre moyen d mm. = average diameter d in mm.; caracteristiques des roues de 1 C.V. pour chute de 1 m. = characteristics of turbine wheels capable of delivering 1 hp. for a head of 1 m.; helice = propeller type; diametre d'entree d'eau d_1 mm. = diameter of orifice, admission of water d_1 in mm.; diametre de sortie d_2 mm. = diameter of exit d_2 in mm.; largeur du distributeur l mm. = width of distributor l in mm.; Vitesse specifique N_s tours par minute = specific velocity N_s in r.p.m.)

different characteristics. (Marcel Mathieu in *Arts et Métiers*, vol. 83, no. 116, May, 1930, pp. 200–202, *p*)

INTERNAL-COMBUSTION ENGINEERING (See also Railroad Engineering: Burmeister-Wain Diesel-Electric Locomotive)

Scientific Research in the United States on Gasoline Engines

AS REGARDS general engine design there is much of what might be termed empirical research on such subjects, as:

a Increasing volumetric efficiency with considerable consideration of supercharging, and the use of superchargers for racing purposes;

b Increased compression ratio with corresponding demands for fuels which will permit higher compression, and incidental studies of fuel characteristics;

c Increased thermal efficiency, which, however, has led to no outstanding results; and

d Increases in mechanical efficiency. The latter might rather be discussed as maintenance of mechanical efficiency at higher rotative speeds.

The outstanding result of these general researches, or design trends, has been increased engine speeds with heavier and stiffer crankshafts, in many cases lighter reciprocating parts, relatively higher volumetric efficiency, and increased compression ratios requiring fuels of better quality as regard knock characteristics. There has been also a careful study of the effect of cylinder-head design on power, smoothness, and knocking characteristics of engines.

In valve springs certain new data have been obtained by the use of an instrument called the electric telemeter. A good deal of attention has been called to the subject of engine cooling, particularly by using liquids of higher boiling point than that of water for the cooling medium. It would appear from this that modern water-cooled engines with slight changes can be operated successfully and more efficiently at a cooling-liquid temperature of 300 deg. fahr.

Prof. C. F. Taylor of the Massachusetts Institute of Technology studied the relative behavior of two types of cylinder cooling and came to the conclusion that the water-cooled cylinder gives distinctly better performance than the air-cooled cylinder in every respect except that of maximum economy at part load. The other features covered by the paper are carburation, ignition, effect of altitude, and phenomena of combustion generally. [H. C. Dickinson (Mem. A.S.M.E.), Bureau of Standards, Washington, D. C., before the Second Plenary World Power Conference, Berlin, 1930, Section 32, Report no. 264, 12 pp., *g*]

MACHINE TOOLS

K O S Abrasive Roll

THIS device, manufactured by Karl Offinger, Stuttgart, Germany, renders it possible to apply drills, lathes, and flexible-shaft machines to the grinding of wood or metal parts. Essentially, the tool comprises a cylindrical body bearing upon its outer surface a covering of sandpaper or emery cloth that can be readily replaced. The design of the cylindrical body permits renewal of the abrasive covering in about 10 sec. so that the tool is continually ready for use, and is adapted to mass-production purposes. Since the abrasive covering may be suited to the nature of the product, the tool may be employed for a large variety of work. (See Fig. 2.)

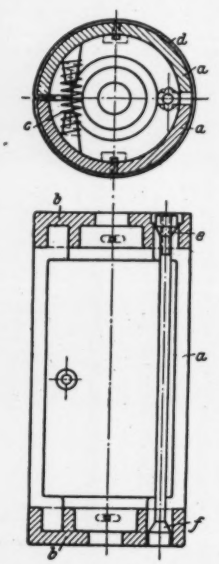

FIG. 2 K O S ABRASIVE ROLL

(*a*, cylinder frame sections; *b*, end caps; *c*, pressure spring; *d*, abrasive cloth; *e*, taper nut; *f*, taper head.)

The same firm also builds a special grinder adapted to using the abrasive rolls described above.

The spindle runs at 1200 r.p.m. and is given a simultaneous oscillating axial movement of 600 strokes per min., the combination of two motions producing a smooth finish free from all marks. (*Engineering Progress*, vol. 11, no. 4, April, 1920, p. 90, 2 figs., *d*)

MARINE ENGINEERING

Marine Diesel Installations With Particular Reference to Auxiliary Machinery

STEAM and electric as well as compressed-air auxiliaries are discussed.

In the earlier steam-auxiliary installations all of the steam was raised in oil-fired boilers while waste-heat recovery from the exhaust was not considered. This resulted in a very uneconomical installation, the auxiliary consumption at sea being rarely less than 25 per cent of the main consumption and frequently as high as 50 and even 60 per cent. In a few instances combined waste-heat and oil-fired boilers were adopted in conjunction with engine-driven pumps for all engine auxiliary services. This formed an efficient combination as steam was only required for steering gear, lighting, and heating at sea, and this could be generated by the waste heat with little help from the oil firing. The author believes that the combined waste-heat oil-fired system did not come into favor because the satisfactory results obtained were never made public in the technical press or in papers read before technical societies.

This led at first to the general adoption of electric auxiliaries with Diesel-driven generators. During the last year or two the combination of electrical and waste-heat-steam auxiliaries has met with some favor. But up to the present, engineers do not seem to have taken full advantage of the possibilities of this system.

The waste-heat boiler, properly adapted with Diesel-electric auxiliaries, seems to offer possibilities for saving in first cost in some types of ship, if the installation is carefully worked out. The most suitable vessel for such an installation would be a general cargo boat in which little auxiliary power is required at sea, while there is a considerable load in port when winches are working. In a vessel of this class waste heat would provide sufficient steam for auxiliary services at sea if some of the pumps were driven from the main engine. By arranging the boiler so that waste heat and oil firing can be used together, it would be possible also to have the standby pumps and pumps for occasional use, i.e., ballast, etc., steam driven, while for port use Diesel generators of the net power required could be provided, a steam-driven standby generator being fitted, as its cost would be considerably lower than that of a standby Diesel set. Such an installation would show excellent economy in fuel and should be much lower in first cost than an all-electric installation. The foregoing remarks apply to one class of ship only, but it can readily be seen that the general arrangement can be adapted to suit the auxiliary load in many types of vessel. The main objection to such an arrangement is the use of steam and electric auxiliary machinery in the same ship which many engineers consider to be bad practice. It would, however, be possible to arrange the auxiliary installation in such a way that, except in case of emer-

gency, only one class of auxiliary would be working at any one time. If such an installation can show in practice the advantages that appear in theory, its further development will be of the greatest value.

In this connection the author describes a particularly interesting arrangement recently adopted on a number of small coasters. In these boats the main engine drives all pumps normally required at sea while a 37-b.hp. auxiliary engine is coupled to the pumps required for various occasional services and for standby for the main engine pumps; a generator is also coupled to this unit.

The choice of the type of boiler must depend on the quantity of steam required under various conditions. For certain conditions the author recommends the three-furnace Scotch boiler using waste heat in the center group of tubes and fitted with oil firing for the wing furnaces. If a combined steam-electric installation is desired, a vertical composite boiler which can use waste heat and oil firing together would be suitable. This may be of either the fire-tube or thimble-tube type, having about the same heating surface for oil firing as for waste heat. (J. Calderwood, paper read before the Manchester Association of Engineers, abstracted through the *Marine Engineer and Motorship Builder*, vol. 53, no. 633, June, 1930, pp. 228–232, 2 figs., *d*)

MOTOR-CAR ENGINEERING

British Car With Three-Cylinder Two-Stroke-Cycle Engine

AN AUTOMOBILE with a three-cylinder, two-stroke-cycle engine was tested by J. Barrington Budd in England. The engine is of the three-port valveless type using crankcase compression and gas distribution by means of ports controlled by the usual deflector-head type of piston. The whole upper part of the engine, i.e., cylinder, cylinder head, and the top half of

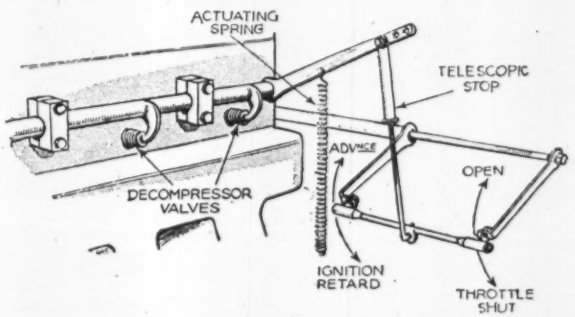

FIG. 3 DETAILS OF THE DECOMPRESSOR CONTROL IN THE BARRINGTON BUDD TWO-STROKE-CYCLE ENGINE

the crankcase, is a one-piece casting comprising water jackets, inlet and exhaust ports, and transfer passages.

So far the engine is of the conventional two-stroke design, apart from its very complete safeguards against compression leakage; in this state it will give the usual two-stroke performance, and the usual two-stroke defects of irregularity at low speeds; but a very ingenious control automatically operating a decompressor converts it into a docile engine at small throttle openings. In each cylinder, just above the exhaust port, is a small spring-loaded valve, which closes an auxiliary exhaust port discharging into the exhaust manifold. A control bar opens these valves by means of a link interconnected with both throttle and ignition controls.

When the throttle is closed these valves are opened slightly; when the ignition is retarded as well, the valves are opened to their fullest extent. The effect is that of shortening the power stroke by increasing the exhaust-port area.

In action the engine was remarkably good. Starting from cold was instantaneous, and the engine called for no warming up to run regularly. Acceleration was excellent for the size of engine, and power, especially at low speeds, was remarkable, for after steady running at about 6 m.p.h. the engine would respond to the throttle even on slight inclines. The six-cylinder torque of the three-cylinder two-stroke engine allows extraordinary top-gear work in traffic.

As there are only seven moving parts in the engine it should be produced at a very low cost. (*The Autocar*, vol. 64, no. 1805, June 6, 1930, pp. 1130, 3 figs., *d*)

Economy of Operation With Heavy Fuel

SOME unpublished results obtained with compression-ignition-engine vehicles operating under service conditions in England are reported here.

So far heavy-oil engines in England have been applied mainly in connection with the transport of heavy loads by vehicles working with and without trailers. It is claimed in this connection that the driving of such heavy-oil-engine vehicles presents no big difficulties to men accustomed to the handling of carburetor-type engines.

The first instance reported is that of a Mercedes-Benz 80-hp. six-ton truck. Between Aug. 1, 1929, and March 31, 1930, the vehicle ran daily over a main-road route covering, out and home, a distance of about 215 miles. It was loaded both ways, the average load throughout the period being 5 tons, 14 cwt. A total mileage of 29,142 was covered on 2442 gal. of Pratt's Grade A Diesel oil, costing $4^1/_8$ d. per gal., so that the cost per mile for fuel was 0.34 d. During this period 59 gal. of lubricating oil were used, giving an average of 493 m.p.g. This comparatively high consumption was the result of changing the oil every 3000 miles. Only one involuntary stop was experienced other than those caused by tire trouble. The total fuel figure includes a certain quantity wasted, and on a straight run over 13 m.p.g. has been reached with this vehicle. The machine, which weighs 12 tons, 7 cwt. laden, including 1 ton, 14 cwt. for the body and six-ton load, has a rear-axle ratio of 6.3 to 1, which gives a maximum top-gear speed of 29 m.p.h.

The economy of the machine will be better appreciated when it is mentioned that the best result with the same firm's five-ton gasoline-engined lorry has been about 6 m.p.g. of No. 3 power spirit. Further economy is due to the fact that the Mercedes-Benz is run with only one man, whereas two have been found necessary with the gasoline vehicles.

After 13,433 miles one exhaust-valve spring broke and during its replacement the engine was examined. Very little carbon was found and there was no pitting of the valves. It was only after 20,000 miles that other troubles of minor character were found.

Data are given on the performance of another Mercedes-Benz heavy-oil-engine truck as well as of six- to seven-ton Deutz-engined Berna vehicles obtained by a firm of users who operate a large fleet of Berna machines of both gasoline and heavy-oil-engine types. Tabulated results in the original article refer to more than 30 journeys between London and a number of provincial towns. The Berna machines are of Swiss origin but are built in England.

An interesting report is given on the operation of a Saurer-type seven- to eight-ton truck. When carrying a seven-ton paying load the high-geared or super-geared vehicle consumes a gallon of heavy oil for 11 to 12 miles running, the lubricating-oil consumption being approximately 1000 m.p.g. Tests of a low-gear machine hauling a trailer and carrying a total load of 15 tons have shown the fuel consumption to be 9 to 10 m.p.g. and the lubricating-oil consumption to be between 900 to 1000 m.p.g. (P. M. Sanders, *Motor Transport*, vol. 50, no. 1313, May 12, 1930, pp. 550–551, *p*)

MOTOR-CAR ENGINEERING

Millam Free Wheel and Sprag

THIS appliance is manufactured by Sir W. G. Armstrong-Whitworth & Co., Scotswood Works, Newcastle-upon-Tyne, and is intended for insertion in the propeller shaft of a motor vehicle.

The construction of the mechanism is shown in Fig. 4. The gear is virtually an automatic metal-to-metal clutch fitted with rollers. The drive in the apparatus as applied to ordinary cars is taken between the outside faces of six segments and the inside surface of a driven drum. The rollers themselves are not called upon to take the drive between the driving and driven members.

The driving portion of the free wheel consists of a cage *G*, Fig. 4, for the rollers, which is provided with six jaws *C*, between each of which lies a pair of rollers *D*. On the outside of the rollers and immediately inside the drum and its liner, *A*, *A'*, respectively, are six driving segments *B*, which are shaped on their inner faces to form double-acting wedges, their outer faces being ground to the same curvature as the inner surface of the drum liner with which they engage when under load. On the inside of the rollers is a hardened-steel roller path *E*, keyed to a box inside the driven drum.

It is claimed that the fact that the roller path is an integral part of the driven drum is very important as it means that the radial thrust on the segments necessary to enable them to take the drive is completely balanced within the one driven member and that there is therefore neither radial thrust nor end thrust between the driving and driven members, the gear acting as an ordinary dog clutch in which the driving members and the driven portion make a rigid structure formed by the roller path, rollers, segments, or drums, so that no slip can take place no matter what torque is transmitted, provided, of course, that the angle of the wedge surfaces of the segments is less than the angle of friction between the segments and the drum. The matter of best angle is very important.

Another function of the roller path is to cause the rollers to rotate slightly, by reason of the momentary and slight relative rotary movement of the roller cage and roller path, when the load is on the point of being taken up. This slight rotation of the rollers causes the outer rollers to roll positively along the wedge surfaces on the inner faces of the driving segments and helps the action of the drum itself in dragging the segments over the rollers. This action, it is stated, gives a sure and instantaneous take-up of the load and eliminates the possibility of slip. As has already been mentioned, the roller path also takes the reaction of the outward radial thrust on the segments.

When the mechanism is used purely as an over-running device, the wedges are restrained from rotary movement in one direction, relatively to the cage, by means of axially sliding fingers *H*, so that no wedging action can take place when the car overruns the engine. When, however, it is desired to use the mechanism as a solid coupling, the restraining fingers are withdrawn, whereupon the wedging action can take place in both directions of rotation whether the engine is driving the vehicle forward, is being used as a brake, or is driving the vehicle in reverse. The six axially sliding fingers are actually made in the form of prongs *H* on the side of the grooved controlling sleeve *K*, in which groove lies a shoe or cod-piece attached to an operating fork.

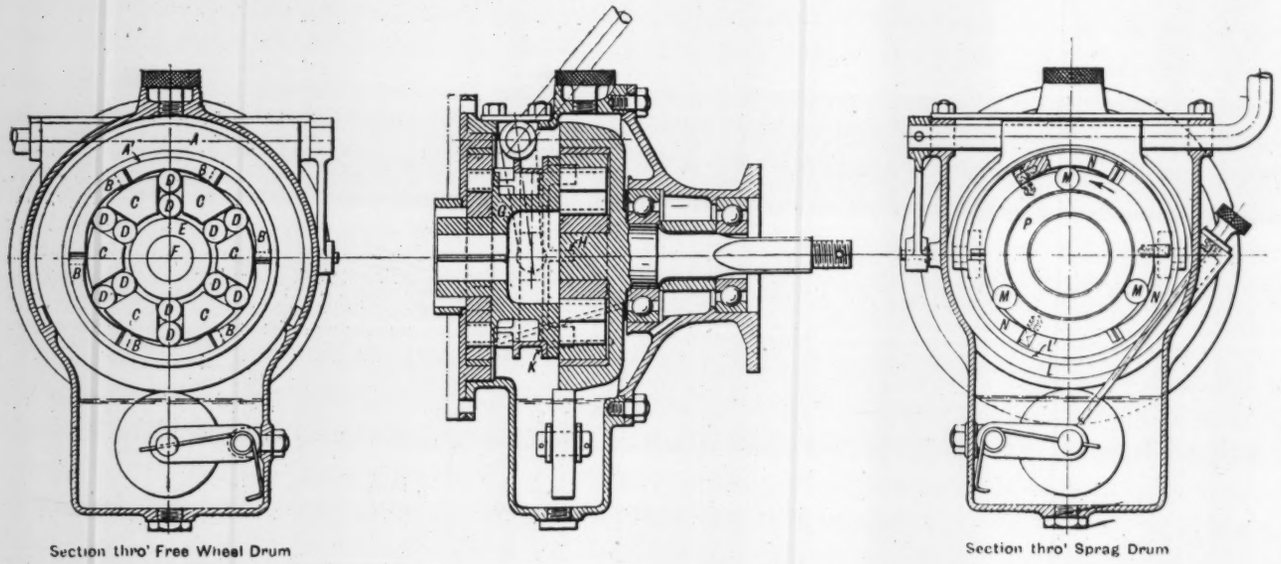

FIG. 4 MILLAM FREE WHEEL AND SPRAG
(This figure does not show the sprag as actually used in ordinary vehicles.)

When the free wheel comes into action it does not do so with a hammer shock, as the double-wedged segments have first to squeeze out a film of oil before actual metal-to-metal contact takes place, and the squeezing out of the oil introduces a time factor which results in the gear coming into action without jar. The moment metal-to-metal contact takes place, there is no further slip or creep, the angles being such that the greater the torque, the greater the grip.

Embodied in the same casing as the free-wheel mechanism is an automatic sprag which prevents a vehicle, when stopped on a hill, from moving backward, even though the brakes are off and the gears are in neutral. The moment the vehicle stops, the wheels are automatically locked.

The sprag mechanism is described in some detail in the original article. (*The Engineer*, vol. 149, no. 3884, June 20, 1930, pp. 696–695, 3 figs., *d*)

NATIONAL DEFENSE (See also Foundry: Centrifugally Cast Alloy-Steel Guns)

Defense Against Gas

THE author divides his subject into two sections: protection against all known war gases other than mustard gas, and

protection against mustard gas. The former is dealt with very briefly. As regards mustard gas it is stated that the British Army alone had over 160,000 casualties from this gas during the last fifteen months of the war. It is a fact, however, that nearly 90 per cent of these casualties could have been prevented by wearing the respirators then carried by all ranks. It was mainly due to a lack of knowledge of and training in the peculiarities and insidious nature of this gas that this great wastage of men occurred. Mustard gas is very persistent; both in liquid and in vapor form it penetrates all ordinary clothing or affects all parts of the body with which it comes in contact; the odor of it is not very strong nor very unpleasant nor has it any immediate irritant effect, and it may be many hours before the effects of the gas show themselves. The gas in the forward areas can be distributed by artillery shells, spraying, and local contamination bombs, which could be exploded electrically or by delay-action fuses. In the back areas it may be spread by air bombs or by air spray. The last method of distribution must be regarded as the most dangerous form in which mustard gas may be encountered, as it is the one by which liquid mustard gas can be placed on targets or personnel, as well as on ground or material. To be effective under average war conditions, spraying, in the opinion of the author, must be carried out from low heights and by pilots who are well trained in the art. These spraying attacks would be most effective on nights when there is no wind and roads are congested with troops on the move. Very large zones can be effectively covered in this way by a comparatively small quantity of liquid.

Supply is the crux of the whole matter, where the employment of gas is concerned, owing to the large quantities required for effect.

To cover an area of ground, 100^x by 100^x, would require either 300 18-pdr. shells or 110 4.5-in. shells. An area, 1000^x by 1000^x, would thus require 30,000 18-pdr. or 11,000 4.5-in. howitzer shells (the equivalent of some 225 30-cwt. lorry loads). Such large areas are, therefore, entirely out of the question, except under stabilized conditions of warfare.

For spray areas, 1 gal. of liquid on an area 7^x by 7^x, must be taken as a minimum to be effective; thus some 200 gal. would be required for an area 10,000 sq. yd., i.e., 100^x by 100^x, or, 2000^x by 5^x.

The length of time mustard gas will persist depends largely on weather. Under 8 deg. cent. it will freeze, so although not dangerous at the time under these conditions, it will become so again when the temperature rises and melts it.

On a hot summer's day (European) even a very heavily contaminated area is likely to be sufficiently safe to permit troops to traverse such an area within four hours after being put down. It must be remembered, though, that during that time, a very high concentration of vapor will be given off.

The detailed analysis of the method of laying the gas and protection against it cannot be abstracted here because of lack of space. The conclusion to which the author comes is that we can never hope to avoid a large percentage of casualties in the future unless training in peace time is designed to include a thorough instruction of all ranks in the characteristics and peculiar properties of this gas in the wearing and care of the respirator and in special machines for protection in the field. (Capt. D. Dunlap, R. A., lecture delivered at the Society of Military Engineers, Chatham, Nov. 28, 1929, abstracted through *The Royal Engineers Journal*, vol. 44, June, 1930, pp. 209–219, *p*)

POWER-PLANT ENGINEERING

Diesel-Steam Plant in a Printing House

THIS article deals with an installation of a Diesel engine as an addition to a steam-engine plant in a printing and office book manufacturing company in Kansas City, Mo. Interest in the article lies in the fact that it supplies a careful analysis of the costs, installation and operating, of such an addition if made in the form of an expanded steam plant, purchased power, or Diesel engine, and contains a table showing the cost of the items that go into total cost, comprising the actual costs of steam plant in 1927, two plans for using purchased power, and the cost of a Diesel-engine plant. It also describes in detail some troubles which occurred when the new plant was started. These troubles were found to be due to insufficient drying of the motor insulation (Bransford W. Crenshaw, Consulting Engr., Henrici-Lowry Engineering Co., Kansas City, Mo. in *Power*, vol. 72, no. 2, July 8, 1930, pp. 50–55, illustrated, *d*)

Turbo Set for 1000-Deg. Fahr. Steam Temperature

BRIEF reference and first photograph published in England of the 10,000-kw. unit built for the Delray Power Station of the Detroit Edison Co. This turbine is run at 3600 r.p.m. with steam at 400 lb. per sq. in. pressure and 1000 deg. fahr. total temperature, said to be a much higher temperature than has been tried anywhere else in the world. When the steel is heated at this temperature it is just visibly red in a darkened room. According to the original article the initiated will realize what a sensational attack on the problem of growth of metals at high temperature and on the considerably diminished tensile strength at such a temperature this represents.

The author of the article, which appears in a British publication, adds that American engineers are much to be envied. They can try out new ideas which in England are to all intents and purposes prohibited. Certainly no British public supply undertaking would dare to venture upon such a fascinating experiment. (*The Electrical Times*, vol. 77, no. 2008, Apr. 17, 1930, p. 781, illustrated, *d*)

The Steam Economizer

THE fundamental difference between the economizer and the boiler is that the latter depends for its efficiency upon a rapid circulation. As a consequence of this circulation all of the heating surface is maintained at a practically uniform temperature regardless of the progressive cooling of the gases in contact with it. In no circumstances therefore can the boiler absorb further heat from the flue gases after these have been reduced to the temperature of the steam being generated. In the economizer there is no such limitation as there is no circulation of water. In the ideal design the water would flow steadily in one direction, while the flue gases flowed steadily in the other, so that in spite of the increasing coolness of the gases they would always be in contact with metal which was cooler still.

This indicates a distinction between the scope of a boiler and an economizer. Recently, however, there has been a gradual encroachment by the economizer upon the functions of the boiler which has resulted in the development of the steaming economizer, as indicated by Humphrey, Buist, and Bansall in their recent paper before the British Institution of Electrical Engineers dealing with the Billingham power plant.

Each of the Billingham boiler units is designed to generate normally 215,000 lb. of steam per hr. at a pressure of 715 lb. per sq. in. abs., from water fed to the economizer at a temperature of 401 deg. fahr. The total heating surface of the boiler, including that in the furnace, is 10,020 sq. ft., to which must be added an economizer surface of 23,030 sq. ft. The relatively enormous size of the economizer will be at once remarked, as in modern practice an economizer has rarely more than half as much heating surface as the boiler to which it is attached. In return for its size, the economizer is said to contribute about 30 per cent of the total steam production of the unit. Its further advantages are

said to be a saving of space and the elimination of baffles in the boiler, with a consequent reduction in the fan power required.

From this it would appear that it is hardly likely that a boiler unit comprising a steaming economizer can be more efficient thermally than one following more usual lines, as the limit of possible efficiency has been practically reached. If, on the other hand, it can be shown to be cheaper or more advantageous in any other way to cause the economizer to act partly as a steam generator, we may be on the eve of far-reaching changes in boiler design. (Editorial in *The Engineer*, vol. 149, no. 3880, May 23, 1930, p. 578, *cg*)

The Billingham Power Plant

THE power plant at the works of Synthetic Ammonia and Nitrates, Ltd., at Billingham-on-Tees, has been the subject of considerable discussion among English engineers and has now been described in a paper before the Institution of Electrical Engineers (complete paper, by Humphrey, Buist, and Bansall, not available). The plant is probably the largest high-pressure private steam-generating unit in the world. The electrical load is about 37,500 kw. continuously. The steam pressure is 800 lb. per sq. in. (max.) with a temperature of 856 deg. fahr. (max.) on eight boilers, each rated at 215,000 lb. normal evaporation. High-pressure steam is passed through three 12,500-kw. back-pressure turbine sets, exhausting at 275 lb. per sq. in. Automatically controlled reducing valves are also in parallel with these sets and the steam at 275 lb. is then utilized for process requirements and for two 12,500-kw. condensing turbo-alternators as well as for three 6000-kw. feed-heating turbo-alternators, the steam from the latter being wholly bled and used to feed a large four-effect distillation plant, raising the feedwater to 335 deg. fahr. This latter temperature is subsequently raised to 414 deg. fahr. by a heater using 275-lb. per sq. in. steam, and to 523 deg. fahr. by Foster steaming economizers.

The process plants normally consume 6930 metric tons of steam per diem (1 metric ton = 1000 kg. = 2204 lb.) which represents very nearly 60 per cent of the boiler output. Of this quantity 3994 metric tons per diem are returned as condensate, so that 2936 metric tons are required to be made up by distillation. Mention has been made of the four-effect distillation plant operated in connection with the feed-heating turbines; this normally provides 1188 metric tons per diem with two turbines running. A six-effect distillation plant is also provided using steam at 30 lb. per sq. in. from process plants, and the total capacity of the entire distilling equipment is between 7000 and 8000 metric tons per diem—a figure which has probably never before been reached in any boiler-feed plant of this kind.

With back-pressure and condensing sets, together with reducing valves, the plant is obviously complicated and might conceivably become unstable both as regards loading and steam pressures. Accordingly a comprehensive automatic system of control has been evolved which is used to maintain the electrical frequency and steam pressures under all conditions. The process-steam pressure is controlled by adjustment of the back-pressure turbine governors and the reducing valves, and the frequency by adjustment of the governors of the condensing sets. Control is by means of impulses sent out from a motor-driven drum carrying four segments, each of which generates impulses at a constant rate, the rate depending on which segment is in use; the selection of the segment is effected by a device responsive to steam pressure provided with contact-making segments corresponding to those of the drum. This interaction results in impulses that become more rapid as the steam pressure deviates from normal. An impulse system is also used for frequency control, in conjunction with Warren clock equipment.

Automatic synchronizing gear and automatic feed-pump controls are also in use—and the main feed pumps, incidentally, are driven by 900-hp. motors. Lopulco pulverized-coal firing is used, with horizontal turbulent burners. Each boiler has a total heating surface of 10,020 sq. ft., each superheater 5000 sq. ft., each economizer 23,030 sq. ft., and the air preheater 37,000 sq. ft., the final gas temperature being 230 deg. fahr. The plant uses approximately 1280 tons of coal per diem, and is claimed to produce electric energy at the bus bars at a cost "well below the unit cost of any electrical generating station in the world depending on coal as fuel." This claim was attacked by C. H. Merz in the discussion of the paper in London, but is probably well founded if the whole of the circumstances are taken into account and capital costs are excluded. It is seldom that such large evaporating plant is required, for instance, and it would be interesting to know what proportions of the costs for this are allocated to power and process, respectively. (Editorial in *The Power Engineer*, vol. 25, no. 290, May, 1930, pp. 174–175, *dA*)

RAILROAD ENGINEERING (See also Testing and Measurements: Measurement of Rail-Head Wear)

Burmeister-Wain Diesel-Electric Locomotive

THIS engine is of a new type in that uniflow scavenging has been adopted. The exhaust gases are controlled by a piston valve with a diameter of about half that of the working cylinder and is located in the center of the cover. Scavenging air is admitted through ports which extend around the circumference of the cylinder liner at the bottom of the stroke. These ports are arranged tangentially so that the air charge is given a strong rotary motion. This gives a steady flow to the air stream; and it is claimed that the rotation persists up to the end of compression and is beneficial to combustion in that it assists in the distribution of the fuel charge. The exhaust piston valves are driven through a rigid crosshead and side-rod mechanism by means of eccentrics on the main crankshaft. The engine is a two-stroke-cycle, single-acting, trunk-piston type of the enclosed six-cylinder locomotive design with airless injection. It is direct coupled to a direct-current generator but employs no elastic coupling or flywheel. Each cylinder has a single automatic fuel valve of conventional design. (*The Railway Engineer*, vol. 51, no. 604, May, 1930, pp. 200–201, illustrated, *d*)

George Bennie Monorail-Plane

THIS system of transportation was shown at the Transport Congress in Glasgow, July, 1930. The car suspended from an overhead rail is driven by two propellers—one front and the other rear—with power drawn from the overhead rail. The intention is to use an overhead track made up of a trestle work from which is suspended the rail to support the rail-plane and to use the overhead transportation for the carriage of passengers and the regular rail for freight hauling. It is said that the car will contain twenty-five passengers and will make a speed of 150 m.p.h.

Suspended railroads are not new. The Langan suspended railway near Elberfeld, Germany, has been successfully operated for twenty-seven years and has not had a single accident either to passenger or to employee. In test runs it has attained a speed of 137 m.p.h. The German line is operated, however, by motors geared to wheels. It should be clearly noted that the Bennie Monorail is not of the gyroscopic type, the car being fully suspended from the rail.

It is pointed out that the monorail plan fits in with another plan which is already under way in some places. This is to place a deck over the existing railways to serve as an express motor

highway. (*N. Y. Herald Tribune*, July 6, 1930, Section IV, pp. 1–5, *d*)

Wyss-Krupp Turbine Locomotive

THE first turbine locomotive recently installed on German State Railways was built jointly by Escher-Wyss & Co. and Friedrich Krupp & Co. This locomotive is equipped with a forward and a backward turbine of the Zoelly type. They are located on the two sides of a gear (Fig. 5) set between the frames at the forward end of the locomotive and equipped with a housing split in two. The forward turbine has a normal output of 2000 hp. at 6800 r.p.m. It drives through a gear located on the turbine shaft on to a lay shaft and from there drives in the usual manner

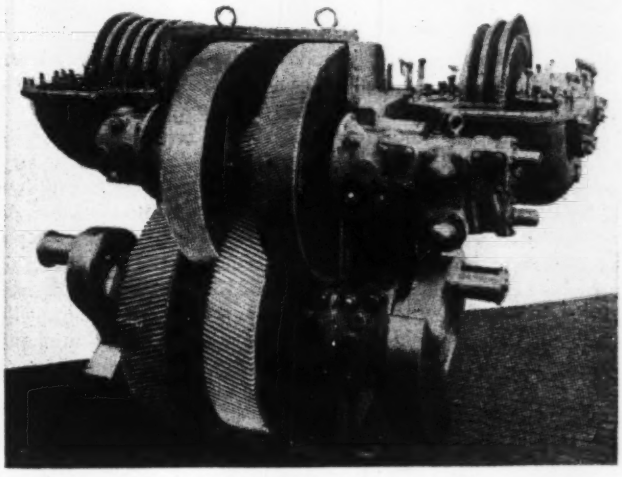

FIG. 5 DRIVING GEAR OF THE WYSS-KRUPP GERMAN TURBINE LOCOMOTIVE

through drive and connecting rods to the driving wheels of the locomotive.

The boiler is of the usual locomotive type. The exhaust of the turbine is condensed in two surface condensers located crosswise to the turbines under the boiler. Behind the condensers is located the auxiliary machinery driven through a turbine of its own and comprising circulating pump, feedwater pump, and air compressor, but not the furnace draft fan. A water-jet air pump is installed for pumping the air from the condenser and receives its water from the circulating pump. Ahead of the exhaust-gas preheater is located an exhaust-steam preheater which receives exhaust steam from a "cooler" turbine located on the tender and working with a counter pressure of 1.2 atmos. abs. In this preheater the warm condensate taken by suction from the condenser at a temperature of some 50 deg. cent. (122 deg. fahr.) is preheated to 100 deg. cent. (212 deg. fahr.) and is then conveyed to the exhaust-gas preheater in which the temperature of the feedwater is raised to some 130 to 140 deg. cent. (266 to 284 deg. fahr.).

In the second dome of the boiler is a special tubular water evaporator supplied with water by an automatic steam pump from the cooling water circulation until its pressure attains approximately 4.5 atmos. The steam from this auxiliary boiler can be used either for heating purposes or can be used to compensate for such losses of steam and water as are created by the operation of the safety valve, leaks, etc. On the tender, besides the supplies of water and coal, is the recooling plant which recools the cooling water for the condensers. This recooling plant consists of cells acting singly but set in four superimposed layers and filled with Raschig rings. Inside of this device is a fan which sucks in the air on both sides from the individual cells and blows it out into the open. This fan is driven by a back-pressure turbine through a gear, the steam from the turbine then going into a preheater. With this recooling plant it is possible to recool the water preheated in the condenser and maintain a vacuum in the condenser of about 85 per cent average.

In tests made by the German State Railways with a special test car it was found that by an output of 1200 to 1300 hp. at the drawbar the coal consumption was 0.75 kg. (1.65 lb.) per effective hp-hr. This means a saving in coal of about 40 per cent as compared with a similar reciprocating-engine locomotive of the German Railways. The detailed dimensions of this locomotive are given in the original article. (*Glasers Annalen*, vol. 106, no. 7/1267, Apr. 1, 1930, pp. 90–91, 2 figs., *d*)

TESTING AND MEASUREMENTS

Measurement of Rail-Head Wear

THERE has recently been undertaken by the Way Department of the Cleveland Railway Co. a very careful study of the relative rates of wear on various sections of track, measurements in each case being taken ahead of stops and midway between stops for each section under observation. Records are being made of the number of wheel passes to which the rail has been subjected since it was first laid. When the measurements were decided upon the question arose as to what would be the most satisfactory method of measuring head wear in view of the fact that it was impracticable to remove the pavement every time it was desired to make a measurement. Experiments were made with plaster-of-paris molds but did not prove satisfactory. Because of the extra time required for it to harden sufficiently to remove without breaking and also because the plaster of paris adhered to the rail, it was rather difficult to remove the cast. Mechanical template devices were rejected as being not sufficiently accurate for the purpose. It was finally decided to make the wear templates from lead solder and the following method was developed. Two plaster-of-paris patterns are first made to fit directly on the rail head and down into the groove and to the outside of the rail head and flange lip. These patterns are each about 1 in. in thickness and are placed on the rail as shown in the illustration in the original article. They are good for about fifty templates before it becomes necessary to replace them. These side patterns are quickly sealed with a little fireclay which is also used to form the end walls of the mold. Into the mold thus formed the hot solder is poured. It solidifies very quickly, making it possible to strip the mold very soon after pouring. The resulting rough casting is sent to the machine shop where it is machined down to a thickness of $^1/_4$ in., the shavings being used over again and remelted for other pourings.

The individual record kept in each case is as shown on the typical card, Fig. 6. On the reverse side of the card is shown the original template, superimposed on which will be shown the weak line as indicated by the lead wear template. In each case under observation, an identifying mark is stamped on the rail flange where it is subject to very much wear, so that subsequent templates at intervals not exceeding one year apart, depending upon the volume of traffic which the rail carries, may be made. A sufficient number of locations have been selected for observation so that the results may be considered as fairly representative of track conditions which prevail on the property and for the equipment which is operated.

While the method may be subject to some criticism on the ground that the bottom of the groove and top outside edge of the lip of the rail, upon which depends to a large extent the basis of

vertical wear measurement, are not fixed points, being themselves subject to a certain amount of wear and rusting, it is felt that the amount of such change during the period in which observations will be made will be so small as to be practically negligible, and in any event the error which might thus creep into results is no greater than that which might occur in any other practicable method and will be even less than in some methods.

From the observations made it appears to be clear that there is a very decided increase in the rate of wear just ahead of the stops

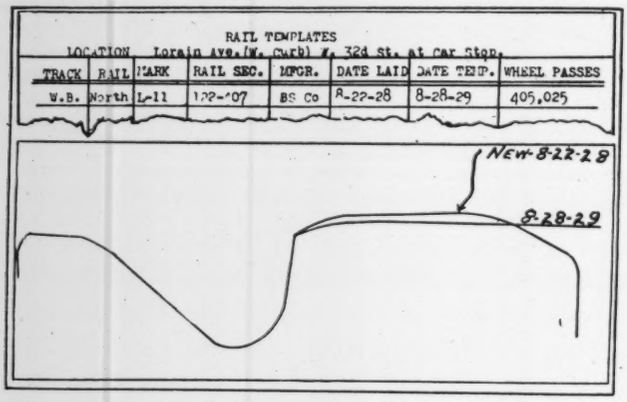
RAIL TEMPLATES
LOCATION Lorain Ave.(W. Curb) & 32d St. at Car Stop.
TRACK | RAIL | MARK | RAIL SEC. | MFGR. | DATE LAID | DATE TEMP. | WHEEL PASSES
W.B. | North | L-11 | 102-107 | BS Co | 8-22-28 | 8-28-29 | 405,025
NEW-8-22-28
8-28-29

FIG. 6 ABOVE—INDIVIDUAL RECORD OF RAIL WEAR KEPT BY CLEVELAND RAILWAY CO.

BELOW—REVERSE SIDE OF CARD SHOWS DIAGRAM OF ORIGINAL RAIL TEMPLATE AND WORN SECTION

but it will probably require at least two more years of observations before it becomes possible to establish any reasonably accurate rule which will hold true for traffic conditions. (Howard H. George, Supt. of Way, Cleveland Railway Co., in *Electric Traction*, vol. 26, no. 6, June, 1930, pp. 301–304, illustrated, *ep*)

THERMODYNAMICS

Note on the Theory of Heat Conduction

THE general equation of heat flow by conduction is

$$\text{div}\,(k\nabla\theta) = c\frac{\partial\theta}{\partial t} \quad \ldots\ldots\ldots\ldots [1]$$

where θ is the temperature at any point at the time t, and k, and c are, respectively, the thermal conductivity and the heat capacity per unit volume of the medium at the temperature θ and at the point in question. It is generally assumed that both k and c are independent of temperature, with the further amplification that otherwise the mathematical difficulties become very great. The author shows, however, that in the majority of instances the variation of k with temperature offers less difficulty than the variation of c with temperature. He introduces a quantity k/c, termed the diffusivity or the thermometric conductivity, and shows that if this quantity is independent of temperature an equation can be derived identical in form with a modification of Equation [1] cited above. Diffusivity, however, is not in general constant, though for non-crystalline poorly conducting solids it is more nearly independent of temperature than either k or c individually. For such materials, therefore, the following equation

$$\frac{k}{c}\nabla^2 u = \frac{\partial u}{\partial t} \quad \ldots\ldots\ldots\ldots [5]$$

with k/c constant is a better approximation than the classical form equation. At any rate the physical properties of the medium in question have been combined into one variable coefficient without loss of generality.

In all problems of steady heat flow, however, the time rates of change of both θ and u vanish, the diffusivity consequently disappears, and Equation [5] becomes

$$\nabla^2 u = 0 \quad \ldots\ldots\ldots\ldots [6]$$

which is identical in form with the classical equation for steady heat flow. It follows, therefore, that if the boundary conditions are expressed in terms of u instead of θ, the problems of steady heat flow with variable conductivity can be attacked by the same general methods that are used in the solution of problems with constant conductivity. In fact, in all cases where the boundary conditions are originally given in terms of temperature, normal heat flux, or a combination of both, solutions for variable conductivity are immediately derivable from the solutions of the same problems with constant conductivity. The general nature of this picture has apparently been overlooked, or at least not generally recognized.

If the boundary conditions are given in terms of differential equations as in the case of heat transfer between a boundary surface and a fluid medium according to some experimental law of heat transfer, such as Newton's law, the solutions for u do not follow directly from the solutions for θ. As an example for the use of Equation [6] the author considers the solution of a problem of a cylinder where one end of a given length and radius is maintained at zero temperature and the other end is insulated. Heat is added at a constant rate to a portion of the convex surface of a given length adjacent to the insulated end, the rest of the convex surface being likewise insulated. Required: The temperature distribution in the cylinder when the steady state has been attained. The author gives a solution for this problem. (M. S. VanDusen in the *Bureau of Standards Journal of Research*, vol. 4, no. 6, June, 1930, pp. 753–756, *m*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

A.S.M.E. Boiler Code Committee Work

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council

of the Society for approval, after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Below are given records of the interpretations of the Committee in Cases Nos. 650, 652–659 inclusive, as formulated at the meeting on June 27, 1930, all having been approved by the Council. In accordance with established practice, names of inquirers have been omitted.

CASE NO. 650

Inquiry: Will a joint formed between a cylindrical shell and a flange for a bolted cover, by slipping over the end of the shell a ring of the full diameter, constitute a circumferential joint as provided for in Par. U-23*b* of the Code, and if so, can it be welded?

Reply: The Code has no provision for the forming of such a bolting flange by slipping a ring over the end of a shell and attaching by fillet welding. A hub flange may, however, be welded to such a cylindrical shell in accordance with the requirements of Par. U-23*b*.

CASE NO. 652

Inquiry: When it is stated in Par. P-195 that a blank unstayed head shall be made as thick as a seamless shell of the same diameter, does that mean that the material of the head shall be of 55,000 lb. tensile strength grade, or its material may be the same as required for seamless steel drum forgings of Class 1 and Class 2, or tensile strengths of 60,000 lb. and 70,000 lb.?

Reply: A dished head is not classified under the terms of the Code requirements as a forging, but is considered as a pressure part formed of steel boiler plate, to which Pars. P-2 or P-3 of the Power Boiler Section of the Code apply, and the tensile strength used in the formula in Par. P-195 shall not exceed 55,000 lb. per sq. in.

CASE NO. 653

Inquiry: Does the reference in Par. P-324 of the Code to Par. P-323 mean that the design of hangers referred to in Par. P-323 apply to hangers as specified in Par. P-324, or does it (the reference to Par. P-323) apply solely to the method of suspension?

Reply: It is the opinion of the Committee that the reference in Par. P-324 to the outside suspension type of setting as specified in Par. P-323 applies only to the type of setting and not to the hangers.

CASE NO. 654

Inquiry: Is it permissible, under the rules of the A.S.M.E. Boiler Construction Code, to construct unfired pressure vessels of open-hearth iron plates?

Reply: Unfired pressure vessels may be constructed of open-hearth iron of flange quality, under the provisions of Section VIII of the Code, provided the material conforms to the requirements of the A.S.T.M. Tentative Specifications for Open-Hearth Iron Plates of Flange Quality (A129 30-T). These specifications are now under consideration by the Boiler Code Committee for addenda to the Code.

CASE NO. 655

Inquiry: Where air tanks are used for starting internal-combustion engines in which case it is desirable that leakage be reduced to a minimum, will it comply with Code requirements if the tanks are connected through individual shut-off or isolating valves to a supply system which is fitted with a safety valve of ample size, and each individual air tank carries no safety valve?

Reply: It is the opinion of the Committee that if air bottles for use in starting internal-combustion engines are connected to the source of compressed air supply through stop valves, they must be provided with fusible plugs, to fuse at a temperature not to exceed 500 deg. fahr., in order to conform to the intent of the requirement in Par. U-3.

CASE NO. 656

Inquiry: Is it the intent of Par. P-308 of the Code which restricts the use of blow-off valves of such a type that dams or pockets can exist for the collection of sediment, to prohibit the use of gate valves because the clearance space below the disk constitutes a pocket?

Reply: It was not the intent of the Code to prohibit the use of a straight-way opening valve in which the pocket is of such shape that there cannot be a sufficient accumulation of sediment to obstruct the flow.

CASE NO. 657

Inquiry: Is it permissible to use for superheaters, steel tubes containing from 0.20 to 0.30 per cent of carbon, the tubes to conform otherwise to the requirements of the Code?

Reply: It is the opinion of the Committee that seamless tubes for superheaters made of open-hearth steel of any carbon content may be used, provided the physical characteristics required by the Specifications for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes are met. A revision of the Power Boiler Code to this effect is under consideration.

CASE NO. 658

Inquiry: *a* Is it the intent of Par. U-40 of the Code to require all flat surfaces of pressure vessels to be stayed?

b Is it permissible to design vessels for operation with unstayed flat surfaces without violating the requirements of the Code?

Reply: *a* Par. U-40 does not require that all flat surfaces be stayed.

b It is the opinion of the Committee that it is permissible to design unstayed flat surfaces and attention is called to the revised form of Par. U-51 of the Code.

CASE NO. 659

Inquiry: *a* Is it the intent of Par. U-1 to exempt from Code rules any pressure vessel not entirely built of Code materials; or is it the intent that for such vessels that part which is constructed of Code materials shall be considered as coming under the rules?

b For a vessel of the class described, is it permissible to stamp the vessel as being of Code construction in accordance with Par. U-66, it being understood that the construction does follow the Code as far as the Code applies?

Reply: *a* The Code for Unfired Pressure Vessels exempts only such vessels as are specified in the italic type note which precedes Par. U-1, and which do not come within the limits specified in Par. U-1. (See Case No. 591.)

b The Code for Unfired Pressure Vessels does not cover all types of vessels and it is the opinion of the Committee that when vessels are not entirely constructed in accordance with Code rules they cannot be stamped with the Code symbol.

Engineering and Industrial Standardization

American Standards Year Book

IMPORTANT progress in standardization work affecting mechanical, electrical, railway, mining, and other major American industries is reported in the American Standards Year Book for 1930, just published by the A.S.A.

The membership of the Association now includes 43 national technical societies, trade associations, and governmental bodies. The Association has, up to the present time, approved 166 national industrial standards, and projects for 171 other standards are under way.

In his review of the underwriting of A.S.A. finances for the next three years, Mr. Serrill lists the following companies as contributing to the underwriting which is intended to provide $150,000 per year for the work of the Association:

Aluminum Company of America
American Telephone and Telegraph Company
Bethlehem Steel Company
Consolidated Gas Company
Detroit Edison Company
Ford Motor Company
General Electric Company
General Motors Corporation
Gulf Oil Company
Public Service Corporation of New Jersey
Standard Oil Company of New Jersey
United States Steel Corporation
Westinghouse Electric and Manufacturing Company
Youngstown Sheet and Tube Company.

Safety on Ships

AN INTERESTING sidelight on the economic phase of accident prevention has recently come to our attention in connection with the transatlantic passenger traffic.

It is reported that during a thirty-month period of operation for five ships, an amount in the neighborhood of $120,000 was actually paid out in settlement of personal-injury claims accruing through accidents occurring on shipboard, and in addition to this, unsettled claims amounted to approximately $1,000,000. A survey of the causes to which the total of 471 accidents on one of the larger ships were attributed indicated that 116 occurred on ladders, stairs, and slippery surfaces such as deck plates, door saddles, etc., 55 were due to the rolling of the ship, 6 were caused by failure to provide walking surfaces offering a sufficiently secure foothold at certain points where conditions rendered such precautions most advisable, and the remainder were credited to a number of miscellaneous causes.

To those familiar with the innumerable polished surfaces appearing in the walkways on most ships, it is not perhaps surprising that accidents should occur, but too few, it is believed, fully appreciate that they form a very considerable percentage of the annual accident toll. The survey made did not of course embrace the shipping industry at large, but it is felt that it may be taken as a typical illustration of the facts which would be brought to light by analyzing records of other shipping concerns.

From both economic and humanitarian standpoints the prevention of accidents is of tremendous importance, and many of these can be avoided by substituting various metals, both ferrous and non-ferrous, embodying in the wearing surface an abrasive material that provides a higher frictional resistance, for the polished surfaces so widely used at the present time in ship construction.

Pressure and Vacuum Gage Standards

FIFTY-FIVE National Societies, Trade Associations, Government Departments, and other organizations have been invited by The American Society of Mechanical Engineers (the sponsor society) to appoint representatives to serve on the Sectional Committee to standardize pressure and vacuum gages. Upon request of the American Standards Association, the A.S.M.E. recently accepted sole sponsorship for the development of standards for pressure and vacuum gages. With the intention of holding the organization meeting of this new committee as early in the fall as possible, these organizations were requested, on July 9, to participate in the development of this project.

NEW AMERICAN STANDARDS

The following standards were approved by the A.S.A. during the months of June 15–August 15, 1930:

Safety Code for the Use, Care, and Protection of Abrasive Wheels, B7. (American Standard.)

Sponsored by the Grinding Wheel Manufacturers of the United States and Canada and the International Association of Industrial Accident Boards and Commissions. Published by the Grinding Wheel Manufacturers of the United States and Canada.

Navigational and Topographical Symbols, Z10h. (American Tentative Standard.)

Sponsored by the American Association for the Advancement of Science, the American Society of Civil Engineers, the American Institute of Electrical Engineers, The American Society of Mechanical Engineers, and the Society for the Promotion of Engineering Education. Published by the American Institute of Electrical Engineers.

Transmission Roller Chains, Sprockets, and Cutters, B29a. (American Standard.)

Sponsored by the American Gear Manufacturers' Association, The American Society of Mechanical Engineers, and the Society of Automotive Engineers. Published by the Society of Automotive Engineers.

Symbols for Photometry and Illumination, Z10d. (American Standard.)

Sponsored by the American Association for the Advancement of Science, the American Society of Civil Engineers, the American Institute of Electrical Engineers, The American Society of Mechanical Engineers, and the Society for the Promotion of Engineering Education. Published by the American Institute of Electrical Engineers.

The Conference Table

THIS Department is intended to afford individual members of the Society an opportunity to exchange experience and information with other members. It is to be understood, however, that questions which should properly be referred to a consulting engineer will not be handled here.

Inquiries will be welcomed at Society headquarters, where they will be referred to representatives of the various Professional Divisions of the Society for consideration. Replies are solicited from all members having experience with the questions indicated. Replies should be as brief as possible. Among those who have consented to assist in this work are the following:

ARCHIBALD BLACK, Aeronautic Division
A. L. KIMBALL, Applied Mechanics Division
H. W. BROOKS, Fuels Division
R. L. DAUGHERTY, Hydraulic Division
WM. W. MACON, Iron and Steel Division
JAMES A. HALL, Machine-Shop Practice Division
CHARLES W. BEESE, Management Division
G. E. HAGEMANN, Materials Handling Division
J. L. WALSH, National Defense Division
L. H. MORRISON, Oil and Gas Power Division
F. M. GIBSON and W. M. KEENAN, Power Division
W. R. ECKERT, Petroleum Division
MARION B. RICHARDSON, Railroad Division
WINFIELD S. HUSON, Printing Industries Division
JAMES W. COX, JR., Textile Division
WM. BRAID WHITE, Wood Industries Division

Wood Industries

Conveyors in Paper Mills

WI-1 What types of conveyors are used in paper mills, and what is the general practice in moving materials and finished products around the plant?

Pneumatic conveyors are used in a number of large paper mills to unload clay from box cars to storage, and to reclaim clay from storage to mixers. The paper industry is using large quantities of English white clay, which usually holds considerable moisture. An Eastern paper manufacturer found a clean, white, washed, dry clay in very find powder form which could be bought and delivered at the plant in bulk in box cars considerably cheaper than the imported English clay. As this clay offered a substantial saving in cost, a handling method was worked out to make the unloading and distribution clean and dustless and to avoid labor difficulties and loss through dust and spillage.

In the equipment used, one intake pipe line is carried along the platform so that it can be used for unloading any one of several cars on the siding without switching. An operator handles the 3-in. intake hose and nozzle which unloads the clay at an average rate of 10 tons per hour.

The receiving station, vacuum pump, and motor are located over the basement storage so that the incoming material is discharged by gravity direct to the mixer or through the screw conveyors to storage. To reclaim from storage, the flexible hose and nozzle are attached to a convenient fitting on the second intake line in the storage room, and the clay is conveyed to the mixer.

A 36-hp. motor is required to maintain the 10-ton-per-hour conveying capacity. Storage space is provided on the top floor of the building so that the material flows from storage to mixer by gravity, thus eliminating the reclaiming line. The flexible hose and nozzles are of the same diameter, that is, 3 in., to provide the maximum flexibility and ease of handling, and a 40-hp. motor drives the vacuum pump which has an unloading capacity of 12 tons per hour.

The moisture content in the clay has run as high as 4 per cent, and this has not interfered with the performance of the pneumatic conveyors. The saving in loss from dust and spillage, the improved labor conditions, and the low labor costs have shown these pneumatic conveyors to be a profitable investment. (E. H. deConingh, The Dust Recovering and Conveying Company, Cleveland, Ohio.)

Questions to Which Answers Are Solicited

Use of Pulverized Coal for Firing Shaft Lime Kilns

F-14 Has a direct-fired pulverized-coal system ever been used to fire shaft lime kilns? If so, give brief description, together with results obtained, difficulties encountered, and data on operation.

Cutting a Groove in Hard Rock

M-14 How can a groove $1/2$ in. deep and from $1/2$ in. to $3/4$ in. wide be machined at one cut in hard rock at a speed of 60 in. to 75 in. per min.? What power will be required to operate the machine, and what material and shape are necessary for the tool?

Time Allowance For Washing Up

Mg-4 What time allowances are made laborers in manufacturing plants for washing up at the end of the morning and afternoon periods, and for lunch about the middle of the morning period?

Drumming Noise of Boilers

P-5 Why do boilers make a humming or drumming noise at certain loads and how may it be eliminated in any given installation?

Causes and Remedies for Cinder Cuts in Boiler Flues of Locomotives

R-4 What are the causes and satisfactory remedies for cinder cuts in the flues of steam locomotives? They occur both inside the firebox above the firebricks at the boiler head and also in the front end or smokebox.

Latest Developments in the Long-Draft Spinning of Cotton Yarn

T-2 What are the latest developments in long-draft spinning of cotton yarn? Has any system of long-draft spinning been generally adopted in this country?

MECHANICAL ENGINEERING

A Monthly Journal Containing a Review of Progress and Attainments in Mechanical Engineering and Related Fields, The Engineering Index (of current engineering literature), together with a Summary of the Activities, Papers, and Proceedings of

The American Society of Mechanical Engineers

29 West 39th Street, New York

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Museums to Inspire Youth

THE announcement that Elmer A. Sperry willed one million dollars to the Y.M.C.A. because it was through this institution that he was given the opportunity of visiting the Centennial Exposition where he received his first great inspiration for mechanical achievement, brings forcibly to attention once more the effective service performed by exhibitions of this sort. While not all the men of Mr. Sperry's generation have thus definitely placed their fingers on the inspiration received at Philadelphia in 1876, no doubt many of them could do so, for this occasion marked an important era in the development of our industrial history.

Since 1876 much thought has been given the industrial-museum idea. In London the Science Museum at South Kensington and in Munich the Deutsches Museum have become world famous. In this country, Chicago, through the munificence of Mr. Julius Rosenwald, has begun work on such a museum, as noted in the October, 1929, issue of MECHANICAL ENGINEERING, and in Philadelphia, Benjamin Franklin's achievements are to be honored by the construction of a beautiful building which will house an exhibition of industrial art and progress and serve to inspire future inventors as did the exposition of 1876. Amid these carefully organized exhibits, future Sperrys will have abundant opportunity to instruct themselves in the accomplishments of scientists, engineers, and inventors, and will find the evolution of important factors of industrial progress graphically displayed for inquiring study.

In this connection the announcement of the Museums of Peaceful Arts, New York City's museum of science and industry, that a special exhibit will be held in the new quarters of the museum in the News Building from September 12 to November 15 is of interest. The exhibit will depict the rise of the Machine Age, and will tell the story of man and machine, through actual machine tools and mechanical agencies, from early times to the present. Engineers visiting New York City during these weeks will find much to interest them, while many young men will have their ambitions stimulated and their latent engineering abilities aroused.

Rapid Changes in Industry

AT THE time of the great anthracite strike nine years ago predictions were made that one of the results of forcing people to do without anthracite fuel at a time when they needed heat in their homes would be to divert their attention from anthracite as the only fuel for domestic heating to other types of fuels.

What was foreseen then is now actually happening. There has been a remarkable growth in the substitution of oil for coal in domestic heating. According to recent data from the U. S. Bureau of Mines, Census Bureau, and other sources, as published by the American Oil Burner Association, in 1921 only 12,500 homes in the United States were heated by oil burners, while today the number is 535,000, and at the present rate of increase there will be 655,000 domestic oil burners in use in 1931. This remarkable increase in the use of fuel oil for home heating is due to a number of causes, the foremost of all of which is the great convenience of the oil burner for homes. But no matter how convenient the oil burner is, its installation is unquestionably more expensive than that of coal-fired heating equipment, and the 535,000 burners installed have involved many millions of dollars of additional outlay, and in many cases outlay for replacement of the coal burner already installed by the oil burner. The nine years since 1921, however, have been years of great prosperity when wages of labor and the average profits of industry were high and people had money to spend for additional conveniences.

In the past it has been considered most difficult to change the basic habits of people, such as their style of dress and manner of living. This was due to slow adaptation to new conditions, lack of money to buy new equipment, and what has been called natural conservatism, but really amounts to ignorance of the new developments due to lack of advertising. It took many years to introduce anthracite as a domestic fuel throughout the country because people did not know about it and did not have enough money to buy new stoves or a willingness to spend money as long as the old stoves to which they were accustomed continued to work.

Today news of improvements is quickly brought to the prospective purchaser, including the housewife, in a manner that demands attention. The buyer has the money to spend and is so sure of continuing to have it that he actually does not fear spending it. The result is a rapidity of change which would have been unbelievable a generation ago in places where changes in the past have not taken place for generations. The change from anthracite to oil burners is only one illustration of this condition.

Another example of this rapidity of change is to be found in the average kitchen. Where formerly everything was either black or drab gray, today the mop, garbage can, and the handle of the potato peeler have blossomed into vivid yellows, greens, and oranges, either to match the color scheme of the house or the lineoleum in the kitchen, while even the boiler in the basement is either red or piercing purple. Mechanical engineers whose primary function is to provide the machinery and methods for effecting these changes will, of course, welcome the new trend

in the industry, and as much as possible assist it by inventing methods of simplification and reducing the cost of production by cheaper gages, jigs, and methods of manufacturing patterns and die castings.

Prospective Geography of the Steel Industry

IN THE STEEL industry, as in all others, the personal equation is of tremendous importance. In the 'fifties and 'sixties, Cleveland was just as conveniently located for purposes of steel making as was Pittsburgh, but the big men of Cleveland were interested in oil and hence the steel industry went to Pittsburgh, where Andrew Carnegie had found a job when he was still a boy.

Apart from the human element, however, it was the availability of coal that determined the location of the industry. In the days of the Bessemer process, hot metal was the prime requisite for the manufacture of steel, and was still necessary even when the open-hearth process began to develop.

Blast furnaces, from which the hot metal was obtained, required primarily two materials—coal and ore, and experience promptly indicated that it was more reasonable to ship ore to the coal than coal to the ore, because in the shipment of the latter, particularly in the form of friable coke, the losses both in transportation and in the burning of transported coal were excessive, while ore could be carried for long distances and stand any amount of handling without incurring what would have been considered prohibitive losses.

Because of this the steel industry was established at Pittsburgh where coal could then be had at about $1 per ton. The development of ore lands in Minnesota made Pittsburgh still more prominent in the industry by insuring for it an inexhaustible supply of high-grade ore that could be delivered to the blast furnace at a low price.

It is significant in this connection that apparently the item of transportation was predominant in the cost of the ore. As long as transportation charges were low Pittsburgh remained the chief center of the industry. It was only when the freight rates on railroads began to show an upward tendency that a real scattering of the steel industry manifested itself with the establishment of plants at Buffalo, in the Chicago district, and elsewhere.

In the last few years, however, the beginnings of a tremendous change has been noticed. Today the part played by the blast furnace in the manufacture of steel is gradually becoming of secondary importance, and the day may not be far off when all-scrap manufacture will become a predominant rule rather than the rare exception that it is today. With the blast furnace relegated to a second place, the matter of coal transportation acquires a different significance, as coal for use in the open-hearth furnace can be handled with no more difficulty than ore, and this condition would then permit establishment of a steel plant in whatever part of the country it appeared that there was need for one.

When all of these technological changes are completely established, the cost of carrying the finished product to market will become the determining factor and, indeed, it is today a factor of importance, as it costs approximately $1 to haul a ton of steel for a distance of 100 miles. Under these changed conditions the natural location for a steel mill will be where the amount of scrap and the consumption of the steel are large, and where coal can be delivered at a reasonable price. In establishing such a specification for the location of a steel mill the mind instantly jumps to Detroit, a city which produces more steel scrap and uses more steel than perhaps any other place in the United States and hence in the world; and as a matter of fact Detroit is rapidly becoming an important steel-making center in addition to being the largest builder of motor vehicles in the world.

It is said that before the war a large automobile concern in Detroit used to sell all its scrap to a junk dealer for the sum of $1500 a year. Nobody knows how many hundreds of thousands of dollars the junkman made out of this deal and it was not until the universal scarcity of materials during the war made the value of scrap front-page material that this remarkable contract was cancelled. The situation with regard to scrap is fully realized today and other places besides Detroit will probably become sites for new steel mills. It is not impossible that even such a conservative town as New York may develop one.

Noise Abatement

CRITICS of mechanized civilization generally fail to convince us that things are quite as bad as they make out. If ever we are tempted to wish for the return of some rosily tinted past, the thought that many of our modern conveniences and safeguards would disappear decides for today and against the past and we feel a renewed admiration for what man's ingenuity and enterprise have evolved for his comfort and well-being.

But it is folly to blind our eyes to all criticism and to attempt justification of unquestioned abuses that are concomitants of mechanized civilization for which engineers are responsible and which, as time goes on, will be less readily condoned. Certain of these abuses have already run long enough to try the public's patience and loud calls for their abatement become more and more common. Just at present, in New York City, noise is being attacked, as it should be, under the leadership of Shirley W. Wynne, Commissioner of Health.

Just why engineers should postpone noise abatement until public clamor for relief brings the subject into the newspapers, and why they should let leadership in campaigns to lessen it go to doctors and others who find noise a menace to public health, is not clear. It would seem that engineers are content with their technical achievements and are conscious of no obligations to society. Time was when factories were scarcely fit for men and women to work in—getting the stuff out was about all that mattered, never mind the poor devils who had to do the work. And not so many years ago the safety features of machines and processes were neglected with an appalling accident toll as a result. Streams were polluted, the countryside laid waste, and the air befouled with smoke, dust, and fumes in the name of industry and production. Gradually these evils are being abated, and with them, some day, objectionable and unnecessary noise will disappear.

Noise abatement, like smoke abatement, will require eternal vigilance. As in matters of safety, no engineer should consider his problem solved until he has successfully conquered this phase of it; until, in fact, he has honestly appraised every probably objectionable feature of his plans and made an earnest attempt to eliminate them. Reputable manufacturers today do not think of permitting dangerous machinery without guards and safety devices in their shops. The day will come when other objectionable features, such as noise, will be as carefully guarded against, and designers will think of nosie abatement as they think of guards for gears and punch presses.

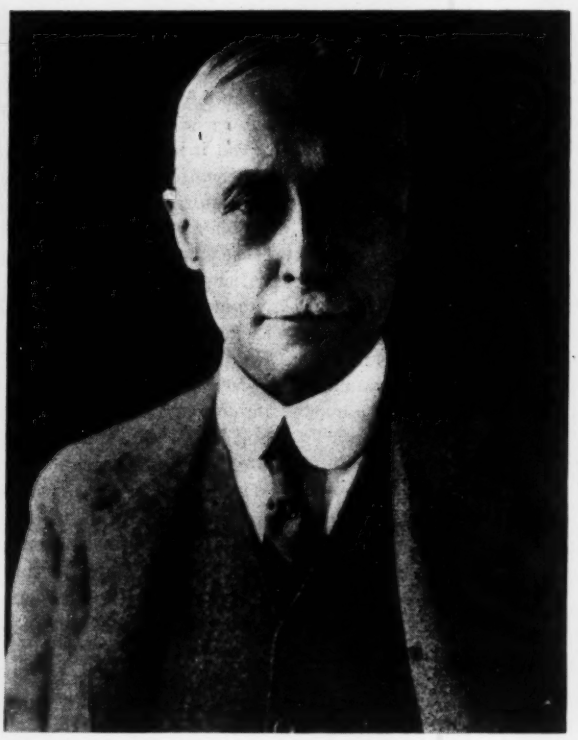
To hasten this day, engineers should look upon objectionable and unnecessary noise as an unjustifiable evil and do all in their power to deserve less the reproach to their unawakened sense of social obligation which it really is. The A.S.M.E. has commenced work on the problem by organizing a special research committee on the measurement of noise, an essential feature that must be determined before much headway can be made in effective noise-abatement.

Elmer A. Sperry

An Active Life Devoted to Engineering and Invention

ELMER AMBROSE SPERRY, past-president of The American Society of Mechanical Engineers, engineer, and inventor, whose name will always be associated with the development of devices involving the gyroscope, died at St. John's Hospital, Brooklyn, N. Y., on June 16, 1930, as a result of complications which set in after he had practically recovered from an operation.

Mr. Sperry was born in Cortland, N. Y., on October 12, 1860. He was the son of Stephen Decatur and Mary Burst Sperry, and a descendent of Richard Sperry who emigrated from England in 1634 and who, in 1666, at New Haven Colony in Connecticut, secreted on his farm in what is now known as Judges Cave, Whalley, Goffe, and Dixwell, three of the regicide judges who had condemned King Charles I to death.



ELMER A. SPERRY

Mr. Sperry attended the State Normal School at Cortland, and spent the college year of 1879–1880 at Cornell University. In 1876, through arrangements made possible by the Y. M. C. A. of Cortland, N. Y., he visited the Centennial Exposition in Philadelphia, and here received an imperishable inspiration for a career of invention. To this experience, which introduced him to engineering and determined his life's work, he paid magnificent tribute by leaving in his will the sum of $1,000,000 to the Y. M. C. A.

One of Mr. Sperry's early contributions to the electrical industry was an improved form of Gramme dynamo for arc lighting and an arc lamp for use with the machine. He secured the adoption of lamp and dynamo, and in 1880 founded the Sperry Electric Company of Chicago in order to manufacture these and other electrical appliances.

In 1883 he erected on Lake Michigan an electric beacon 350 ft. high, the highest in the world, and equipped it with 40,000 candlepower of arc lights.

In 1888 he was the first to build electrical mining machinery. His machines have been widely used, and started a distinct advance in mining.

About 1890, he became a designer of electric street-railway cars and soon founded the Sperry Electric Railway Company of Cleveland, Ohio, to build them. In 1894 the patents were purchased by the General Electric Company. He then designed electric carriages and manufactured them for several years. With a storage battery invented by him he was able to drive an electric carriage the remarkable distance of 100 miles. In 1896 he drove the first American-built automobile in Paris. A number of his electric carriages were sold there.

Electrochemistry also interested Mr. Sperry. He originated a process for caustic soda and bleach which still continues to be used extensively because a second large plant has recently been put into operation. Under other Sperry patents the National Battery Company was organized. He invented a detinning process for recovering tin from old cans and scrap, and an electrolytic process for producing white lead from wastes of copper mines. He invented machinery for producing fuse wires. On this invention the Chicago Fuse Wire Company was established.

In 1918 Mr. Sperry announced his high-intensity arc searchlight, having a brightness 500 per cent greater than that of any light previously made. It has high actinic value and has made possible indoor photographing of motion pictures without the sun. It is a great aid in the navigation of air and water, and is the standard searchlight for the principal armies and navies of the world.

Mr. Sperry devoted much thought, energy, and money to the development of compound internal-combustion engines using low-grade fuel oil. His compound Diesel engine, for a given horsepower, has about one-fifth the size and weight of the ordinary types.

About 1896, Mr. Sperry turned his attention to making practical use of the principles underlying the toy known as the gyroscope. This amazing device appears to have been invented some time in the eighteenth century. It was studied scientifically by Foucault, a French physicist, about 1851. The gyroscope is a wheel with a heavy rim, so mounted that it can spin very rapidly on its axis. When friction is reduced to a minimum and the method of mounting and suspending eliminates restraint by other objects or external forces, the gyroscope tends to point its axis in a definite direction and to return to that direction if disturbed. Possibilities of great usefulness were perceived. By diligent, tedious, and expensive investigation and great ingenuity, overcoming many obstacles, Mr. Sperry skilfully combined electrical and mechanical elements into successful gyroscopic compasses and stabilizers for ships and airplanes.

The gyroscopic compass was completed in 1910 and was first tried out on the United States Battleship *Delaware* at the Brooklyn Navy Yard. Soon after this it was adopted by the U. S. Navy and during the War it was used in the allied navies and subsequently by more than sixty steamship lines. In 1913 the gyroscopic stabilizer for ships appeared. The following year Mr. Sperry entered the field of aeronautics, and on June 14, 1914, his airplane stabilizer was awarded a first prize of 50,000 francs by the French government in a contest for safety devices

for airplanes. The winning machine was piloted by the inventor's son, Lawrence B. Sperry.

These inventions have been great contributions to safety and comfort of navigation of the seas and the air. In some respects they are the most distinctive productions of a remarkably prolific inventor.

Another of Mr. Sperry's inventions is a device for detecting flaws in steel rails. The detector is mounted upon a car which runs along the track at the rate of 6 to 8 m.p.h. Any flaw in the rail is detected, recorded in ink on a moving chart, and its location automatically marked on the rail with white paint.

Mr. Sperry possessed a rare combination of business and inventive ability. Prior to 1910 six companies had been founded to manufacture his inventions with an aggregate annual business in excess of five million dollars. In 1910 he organized the Sperry Gyroscope Company, New York, to manufacture the gyrocompass, ship and airplane stabilizers, high-intensity searchlights, fire-control apparatus, internal-combustion engines, and other products invented by him. In January, 1929, this company was sold to the North American Aviation Company. At the time of his death he was chairman of the board of the Sperry Products, Inc., successor to the Sperry Development Company and the Sperry Rail Service Corporation.

Mr. Sperry obtained more than four hundred patents. For nearly fifty years he was an unusually productive worker in a surprisingly wide area of science and engineering. Many honors were conferred upon him for his achievements. In 1914, as already noted, he was awarded the first prize of the Aero Club of France for his airplane stabilizer. In that year he also received the John Scott Legacy Medal and Premium awarded by the Franklin Institute. Other awards include the Collier Trophy in 1915 and 1916; the John Fritz Medal, 1927; the Holley Medal, 1927; the Elbert H. Gary Medal of the American Iron and Steel Institute, 1929; the Elliott Cresson Medal of the Franklin Institute, 1929; two decorations from the Emperor of Japan, the Order of the Rising Sun and the Order of the Sacred Treasure; two decorations from the last Czar of Russia; and the Grand Prize, Panama Exposition.

Mr. Sperry was a member of the United States Naval Consulting Board and chairman of the Division of Engineering and Industrial Research of the National Research Council. He was a founder member of the American Institute of Electrical Engineers and the American Electrochemical Society; a life member of The American Society of Mechanical Engineers, which he joined in 1910 and which he served as president in 1928–29; and past-president of the New York Electrical Society. He was also a member of the American Chemical Society, the Society of Naval Architects and Marine Engineers, Society of Automotive Engineers, American Petroleum Institute, American Association for the Advancement of Science, National Academy of Sciences, Edison Pioneers, National Aeronautic Association, Franklin Institute, and other technical and scientific organizations in this country. He was an honorary member of the Japanese Society of Mechanical Engineers, the Japanese Society of Naval Architects, the Japanese Society of Electrical Engineers, the Illuminating Engineering Society of Japan, and the Engineering Association of Hawaii. He was a member of the Engineers' Club of New York and numerous other social organizations as well.

Mr. Sperry has been credited with having originated the World Engineering Congress in Japan in 1929. He was elected chairman of the American Committee, of which President Hoover was honorary chairman. . At the Congress he was elected an honorary vice-president and, as leader of the American delegation, took a very active part in the program.

Stevens Institute of Technology and Lehigh University conferred the degree of Doctor of Engineering upon Mr. Sperry and Northwestern University the degree of Doctor of Science.

Mr. Sperry was married in 1887 to Miss Zula A. Goodman, recently deceased, of Chicago. He is survived by his daughter, Helen Marguerite (Mrs. Robert Brooke Lea), his sons Edward Goodman and Elmer A. Sperry, Jr., and five grandchildren. Another son, Lawrence Burst, lost his life flying over the English Channel in 1923 in a plane of his own design.

The Engineering-Drawing Summer School

REPRESENTING thirty-three states and two provinces of Canada, more than one hundred engineers gathered at the Carnegie Institute of Technology from June 12 to 21 inclusive to attend the summer school conducted by the Society for the Promotion of Engineering Education for teachers of engineering drawing and related subjects. Coming as they did from as far west as California and Washington, as far east as New Brunswick and Maine, as far south as Texas and North Carolina, and as far north as Wisconsin and Minnesota, the group especially appreciated the generous hospitality of the Carnegie Institute in housing them in dormitories and in arranging a common dining room which enabled them to become acquainted and to meet daily for the exchange of ideas.

In order to fit the program in between the closing of the colleges and the annual convention of the S.P.E.E., it was necessary to organize a highly concentrated schedule. The sessions opened at 8:30 a.m. and in general continued until late evening, being interrupted only for short intermissions and time out for meals. Practically no time was allowed for recreation and except for the several visits to industrial plants in the Pittsburgh district, visits which in themselves were even more strenuous than regular sessions of the school, practically the entire time was devoted to lectures, demonstrations, and discussions.

The summer school for engineering-drawing teachers was unique in one outstanding respect in comparison with other schools conducted by the S.P.E.E. in that no time was devoted to subject matter, the entire emphasis and attention being focused on methods of organization and teaching procedures. The general plan followed by the school of having a stated topic presented by some leader in the field of teaching followed by formal and informal discussion proved both effective and enlightening, and maintained a sustained interest throughout the entire ten-day period. Twenty-six formal papers by practicing engineers and teachers of engineering were presented to the school.

One of the features of the school was the carefully planned and executed inspection trips to the drafting rooms and industrial plants of the Pittsburgh district. As a part of these contacts with industry, the group was entertained at dinner and given the opportunity to hear those in charge of the drafting rooms discuss the opportunities and responsibilities of college-trained draftsmen, as well as to study the production of drawings and their use in the shop.

The summer school for teachers of engineering drawing was made possible through the generous cooperation and assistance of the Carnegie Institute of Technology. The school was in charge of Prof. H. P. Hammond, Director of Summer Schools for the Society for the Promotion of Engineering Education, assisted by Director William E. Mott, Carnegie Institute of Technology, Prof. Harry M. McCully, Carnegie Institute of Technology, who acted as secretary of the school, and Prof. Thomas E. French, who served as chairman of the teaching staff, and represented the Division of Engineering Drawing of the S.P.E.E.

FREDERIC G. HIGBEE.[1]

[1] Professor of Descriptive Geometry and Drawing, State University of Iowa, Iowa City, Iowa.

Book Reviews and Library Notes

THE Library is a cooperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E., and the A.I.E.E. It is administered by the Engineering Foundation, Inc., as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references on engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

The Aluminum Industry

THE ALUMINUM INDUSTRY. By J. D. Edwards, F. C. Frary, and Zay Jeffries. McGraw-Hill Book Co., Inc., New York, 1930. Vol. I, Aluminum and Its Production, 358 pp., 63 figs.; Vol. II, Aluminum Products and Their Fabrication, 870 pp., 343 figs.; $12.

REVIEWED BY H. W. GILLETT[1]

BESIDES the three authors named, 25 other experts of the Aluminum Company of America have collaborated in the preparation of this book.

Whether one approaches the subject from the viewpoint of the chemical, the mechanical, the metallurgical, or the automotive engineer, or from that of the technician or the executive in industries using aluminum products, he will find much of use and interest in this authoritative compendium. It represents an immense amount of research and development work on the part of the Aluminum Company itself, as well as that resulting in the information given from other sources.

Many of the data have appeared in detailed articles presented to various societies, but have been knit together by the authors into a connected whole, and much hitherto unpublished material has been added. A good deal that, in the earlier days of the firm, was held as trade secrets, has been frankly set forth, according to the modern idea that the engineer who uses a material can use it more intelligently if he is given the facts about its composition and fabrication.

The book is of course written from the Aluminum Company's viewpoint. But no other individual or group could have told so much nor have told it, on the whole, more impartially.

Moreover, while some chapters are of course highly technical, a good deal of the book is very readable, even for the engineer or the business man who may have no specific interest in aluminum. The history of an industry which developed from its small crude beginnings in the hands of the youthful Hall, working with the crudest apparatus, to its present ramifications, has much of romance in it. The industry was born of scientific research and has been nourished by it. No better example is met, in any industry, of the value of finding out the fundamental facts about a material by all the means known to science and then building engineering developments on and applying sales efforts to those uses that need a material of just those properties.

The use of aluminum and its alloys in transmission lines and railway car, automobile, and aircraft constructions, depends on a combination of lightness with electrical conductivity or mechanical strength, as the case may be. In making metal furniture, the desirable mechanical properties of aluminum would not justify its use, unless alloys were available that were easy to fabricate and weld.

In cooking utensils and in the chemical industries, resistance to corrosion is the important feature. The malleability of the metal fits it for fabrication into foil and powder. The reflectivity of the foil fits it for keeping oil tanks cool, and the leafing and covering properties of the powder make it a valuable pigment, not only for purposes requiring reflectivity, but for far wider applications.

Every such application is the fruit of a long train of research and engineering, both in regard to production and to utilization.

The basic fact that it costs money to accelerate and decelerate a railroad car can be translated into the value that any saving of weight will bring. Simple engineering economics shows that aluminum-alloy construction will save money in the long run, and justifies the new developments in large structural shapes. Something of the order of 5 million dollars has been put into a blooming mill to handle 20 × 22 × 72-in. ingots for rolling into large structural shapes, simply because that is the logical path that engineering facts indicate for future development.

When basic facts operate to the disadvantage of aluminum alloys, as is the case with the high coefficient of thermal expansion and the relatively low strength at high temperatures of the alloys when considered for use as automotive pistons, much effort is expended in the attempt to improve those properties. All these and many more subjects are effectively dealt with from the engineering point of view.

Whether one seeks information on metallurgical processes, mechanical properties, or engineering applications, he will find it in the book. It is well indexed and will serve admirably as a handbook for the engineer who wishes to look up the facts in regard to any aluminum product he may wish to use.

To give anything like a complete list of the important subjects covered would take many times the space at our disposal. Suffice it to say that any one wanting any information on aluminum will be well advised to look for it in this book first of all.

[1] Director, Battelle Memorial Institute, Columbus, Ohio.

Books Received in the Library

ARBEIT UND KAMPF; Erlebnisse eines Deutschen Luftschiff-Ingenieurs. By Paul Charpentier. Heitz & Co., Strassburg, 1930. Paper, 6 × 9 in., 179 pp., illus., 4 r.m.

About twenty years ago Gustav Unger designed a rigid airship which was considered by various experts to have several ad-

vantages over that of Count Zeppelin. Since that time the inventor has tried vainly to obtain financial support for the project. This book is an account of his difficulties with governments and competitors, intended to call attention to the invention.

BERGBAUMECHANIK. By J. Maercks. Julius Springer, Berlin, 1930. Bound, 6 × 9 in., 451 pp., illus., diagrams, tables, 21 r.m.

A text and reference book on applied mechanics, prepared to meet the needs of miners and students of mining. Higher mathematics are avoided. The problems and the illustrations of mechanical laws are all derived from mining practice, so that the student is shown how to apply his knowledge directly to timbering, ventilating, pumping, drilling, hoisting, etc.

CONSERVATION OF OUR NATURAL RESOURCES, based on Van Hise's "Conservation of Natural Resources in the United States." By Loomis Havemeyer and others. MacMillan Co., New York, 1930. Cloth, 6 × 9 in., 551 pp., illus., maps, $4.

This book aims to give the general public a presentation of conservation and its problems as they confront us in 1930, which will fill the place filled in 1910 by Van Hise's admirable work. While the book has been almost entirely rewritten, as much as possible has been retained in the words of the original author. The collaborators, authorities in their fields, have produced a very satisfactory work.

ELEMENTS OF FERROUS METALLURGY. By Joseph L. Rosenholtz. John Wiley & Sons, New York, 1930. Cloth, 6 × 9 in., 248 pp., illus., $3.

Presents concisely the fundamental principles and methods involved in the manufacture and fabrication of iron and steel, with the needs of civil and mechanical engineering students in mind, rather than those of the prospective metallurgist. As a result, much detail is omitted, and special attention is paid to matters that affect the mechanical properties of products. The book is an admirable introduction to the subject.

ELEMENTS OF STEAM AND GAS POWER ENGINEERING. By Andrey A. Potter and James P. Calderwood. Third Edition. McGraw-Hill Book Co., New York, 1930. Cloth, 5½ × 8 in., 367 pp., illus., tables, $2.75.

An introductory account of the principles underlying the construction and operation of steam and gas power equipment. Boilers and boiler-room equipment, steam engines and turbines, and their auxiliaries, internal-combustion engines and auxiliaries, plant testing and power applications to locomotives, automobiles, and airplanes are treated briefly. The new edition is revised and has added theoretical material.

ENGINEERING MATERIALS, Vol. 1; Ferrous. By Arthur W. Judge. Isaac Pitman & Sons, New York, 1930. Cloth, 6 × 9 in., 683 pp., illus., diagrams, tables, $8.50.

A revision of the Ferrous volume of the author's "Aircraft and Automobile Materials." Like that work, this one aims to give the engineer and designer, as distinct from the metallurgist, information on the available materials. Physical and mechanical properties, heat treatments, compositions, and applications are emphasized.

The book has also been considerably extended by fuller treatment of cast iron and alloy steels, high-temperature steels, heat treatment, surface hardening, and other topics.

KRUPP; A Great Business Man Seen Through His Letters. Edited by Wilhelm Berdrow. Lincoln MacVeagh, New York, 1930. Cloth, 6 × 9 in., 416 pp., portraits, $5.

The letters cover Alfred Krupp's entire career, from the day in 1826 when his father died, to his own death in 1887. They afford an interesting picture of his struggles to rehabilitate a bankrupt business and to bring it to the leadership in the crucible-steel industry which it finally attained.

LEHRBUCH DER METALLKUNDE. By Franz Sauerwald. Julius Springer, Berlin, 1929. Bound, 6 × 9 in., 462 pp., illus., diagrams, tables, 29 r.m.

Intended as a textbook for university students, this book aims to give a thorough grounding in the science of metals, the study of the properties and behavior of metals and alloys. It is designed to cover the information commonly given in courses on the strength of materials, the testing of materials, the theory of heterogeneous equilibrium, metallography, and technology, but to present it in a systematic, related way. Both ferrous and non-ferrous metals are treated, and numerous references for further study are given.

LEHRBUCH DER PSYCHOTECHNIK, Vol. 1. By W Moede. Julius Springer, Berlin, 1930. Bound, 7 × 10 in., 448 pp., illus., diagrams, 48 r.m.

A comprehensive textbook of applied psychology. The principles of the industrial applications of psychology and the functional analysis of work are first discussed and analyzed. Methods of determining mental and physical aptitudes are explained, and a section is devoted to special tests for certain groups of industrial workers. Much space is given to descriptions of test apparatus and methods.

LOCOMOTIVE CYCLOPEDIA OF AMERICAN PRACTICE. Ninth edition, 1930. Compiled and edited for the American Railway Association—Mechanical Division, by Roy V. Wright and others. Simmons-Boardman Publishing Co., New York, 1930. Cloth, 9 × 12 in., 1440 pp., illus., diagrams, $5.

This reference work is too well known to railway mechanical engineers to need any introduction. The new edition is similar to former ones in plan, but has been enlarged and revised to include new designs of locomotives and appliances. The book continues to be the best exposition of American locomotive practice.

OVERHEAD EXPENSE IN RELATION TO COSTS, SALES, AND PROFITS. By A. Hamilton Church. McGraw-Hill Book Co., New York, 1930. Cloth, 6 × 9 in., 418 pp., $5.

Starting from the fundamental idea that overhead is the cost of maintaining a plant in a condition of manufacturing preparedness, the author develops a method for precisely costing the manufacturing capacity of a plant as a whole, or that of a single process. Once this is done, the further determination of overhead expense in any detail desired becomes, the author says, a mere matter of mechanism. The book expands the principles developed in the author's previous works.

ROBOTS OR MEN? A French Workman's Experience in American Industry. By H. Dubreuil. An authorized translation for the Taylor Society, by Frances and Mason Merrill. Harper & Bros., New York, 1930. Cloth, 6 × 9 in., 249 pp., portrait, $3.

The author, a skilled French machinist and Secretary of Confédération Générale du Travail, came to American in 1927 in order to investigate at first hand factory conditions as they affect the worker. He recounts his experiences during fifteen months in various eastern and middle-western factories and draws conclusions that are, on the whole, favorable to mechanization, scientific management, and human relations in industry as practiced here. A most readable, interesting book.

STATISTIK FÜR DAS JAHR 1928. Compiled by Vereinigung der Elektrizitätswerke. W. Crüwell, Dortmund, 1929. Boards, 9 × 12 in., 635 pp., 50 r.m.

A carefully planned statistical exhibit of the electrical power

plants of Germany and of some plants in neighboring countries. The plants are indexed by names, sources of current, and motive power. Full statistical data are given for each of the electrical power plants mentioned and are also summarized under a group classification.

TABLES ANNUELLES DE CONSTANTES ET DONNÉES NUMÉRIQUES, Vol. 7, part 1. Compiled by Le Comité International, 1930. Cloth, 9 × 11 in., 946 pp., diagrams, $25 per set (2 vol.).

This annual summary of chemical, physical, and engineering facts reviews the new constants and numerical data that have appeared in any of the leading periodicals of the world. Because of its completeness and convenience, it is almost indispensable to research workers in every line. It forms, also, a supplement to the International Critical Tables. The present volume covers the years 1925 and 1926.

TECHNIQUE OF EXECUTIVE CONTROL. By Erwin Haskell Schell. Third edition. McGraw-Hill Book Co., New York, 1930. Cloth, 5 × 7 in., 171 pp., $2.

This book discusses the problems of the executive. The tools of executive control, the duties of the executive, the control and stimulation of subordinates, and difficulties with subordinates, superiors, and equals, are discussed. The author does not offer conclusions or set standards, but rather tries to suggest avenues of reflection that will lead to the acquirement of a successful personal method.

TECHNISCHE TABELLEN UND FORMELN. By W. Müller. Walter de Gruyter & Co., Berlin and Leipzig, 1930. Cloth, 4 × 6 in., 151 pp., 1.80 r.m.

A convenient collection of formulas and tables for electrical and mechanical engineers. Includes the data most frequently wanted relating to heat, the strength of materials, machine elements, and electricity. The volume is of convenient size for the pocket.

VERSUCHE ÜBER TEMPERATURVERTEILUNG. WÄRMEABGABE UND VERBRENNUNGSVERLAUF IN EINEN NEUZEITLICHEN KOHLENSTAUBKESSEL. By E. Kuhn. (Berichtfolge des Kohlenstaubausschusses des Reichskohlenrates, No. 21.) V.D.I. Verlag, Berlin, 1930. Paper, 8 × 11 in., 56 pp., diagrams, tables, 2.50 r.m.

This report contains the results of a test of a modern boiler using pulverized coal, made with unusual precautions to ensure results of practical value. The boiler was tested during actual use. Special measuring instruments and methods were devised to give accurate results. The boiler and the equipment and methods are described in detail, as are the methods of calculation and the results. The work extends our knowledge of the phenomena in the firebox of these boilers.

VERZEICHNIS DER DEUTSCHEN ELEKTRIZITÄTSWERKE, 1928. Compiled by Vereinigung der Elektrizitätswerke. W. Crüwell, Dortmund, 1929. Boards, 9 × 12 in., 314 pp., 15 r.m.

A directory of German central stations except those that use their entire output in their own work. The arrangement is geographic with an alphabetic index. The owners, capacity, voltages, etc., are given in each case.

VORLESUNGEN ÜBER MASCHINENELEMENTE, No. 2; Allgemeine Gesichtspunkte und Verbindungen. By M. ten Bosch. Julius Springer, Berlin, 1930. Paper, 8 × 11 in., 74 pp., illus., diagrams, tables, 6 r.m.

The second instalment of Professor ten Bosch's textbook first discusses in an interesting way the proper preparation of drawings and common faults in them. Such general matters of machine building as the choice of materials, the general design of castings and forgings, and economy in the use of material are then treated. The remaining pages deal with rivets, keys, bolts, welding, and spring fastenings. The book aims to meet the need for a work on the elements of machines formerly filled by Bach's classic work.

DIE WASSERKRAFTWIRTSCHAFT DEUTSCHLANDS; Festschrift zur Tagung der II Weltkraftkonferenz, Berlin, 1930. Deutscher Wasserwirtschafts- und Wasserkraftverband, E.V., Berlin, 1930. Cloth, 9 × 12 in., 391 pp., illus., plates, tables, 25 r.m. For sale by V.D.I. Verlag.

This survey of the hydraulic power resources of Germany and of their present utilization has been prepared for the Second World Power Conference, by German hydraulic interests, with government assistance. General articles deal with the fundamentals of the subject and there are detailed descriptions of the hydraulic power plants of the country, with useful up-to-date statistics. The volume is a handsome one with fine illustrations, and sold at a very low price. It affords a good review of activities in its field.

WEGE ZUR RAUMSCHIFFAHRT. By Hermann Oberth. Third edition of "Die Rakete zu den Planetenräumen." R. Oldenbourg, Munich and Berlin, 1929. Cloth, 7 × 10 in., 431 pp., illus., plates, diagrams, 20 r.m.

Professor Oberth has rewritten his interesting book, which presents the results of his years of experimentation upon rocket flight. Rockets may be used, he says, for meteorological investigations of the upper atmosphere, for aerial photography and surveying, for postal communication, for airplane propulsion, and for interplanetary flight. His book discusses the scientific and engineering problems, the structural details of the rockets, and the various other questions involved.

WEHRE UND SOHLENABSTÜRZE. By Josef Einwachter. R. Oldenbourg, Munich and Berlin, 1930. Paper, 8 × 11 in., 59 pp., illus., diagrams, tables, 7 r.m.

Gives the results of investigations at the Karlsruhe Hydraulic Laboratory upon the flow of water over weirs and the erosion of the bed under various conditions. The erosive effect of various kinds of flow is investigated and methods of alleviating it are discussed. A number of interesting photographs show the actual flow in the experimental channels.

WERKSTOFF- UND BAUVORSCHRIFTEN FÜR LANDDAMPFKESSEL NEBST ERLÄUTERUNGEN. September, 1929, issue with Appendix. Beuth-Verlag, Berlin, 1930. Boards, 6 × 8 in., 94 pp., diagrams, tables.

This new edition of the German boiler code is revised to September, 1929. It contains the specifications and rules governing materials, design, and workmanship, and is accompanied with explanatory notes.

DIE WIRTSCHAFTLICHKEIT DER ENERGIESPEICHERUNG FÜR ELEKTRIZITÄTSWERKE. By Ludwig Musil. Julius Springer, Berlin, 1930. Paper, 7 × 10 in., 143 pp., diagrams, tables, 18 r.m.

A discussion of the economies that may be expected from accumulators of energy by hydroelectric, steam-electric, and combined power plants. Proceeding from general principles, the author develops suitable equations and applies them to specific cases.

ZUR FRAGE DER BEWERTUNG VON HOLZ- UND EISENSCHWELLEN. By Dr.-Ing. Diehl. V.D.I. Verlag, Berlin, 1930. Paper, 6 × 8 in., 58 pp., illus., tables, 3.50 r.m.

A comprehensive discussion of the relative merits of steel and wood ties, based upon the experience of the German railways. The author's conclusions are generally favorable to the case of the steel tie.

Synopses of A.S.M.E. Transactions Papers

THE papers abstracted on this and following page appear in the current issues of Machine-Shop Practice, Oil and Gas Power, and Railroad sections of A.S.M.E. Transactions. These sections have been sent to all who registered in the similarly named Divisions. Other sections are in the course of preparation and will be announced when completed, in later issues of "Mechanical Engineering."

MACHINE-SHOP PRACTICE SECTIONS

PROGRESS IN MACHINE-SHOP PRACTICE. [Paper No. MSP-52-1]

Among the more important developments of the year in machine-tool design, this report states, are the substitution of automatic for hand operation; the tendency away from the single-purpose machine and toward standard tools with specially designed fixtures for definite production jobs; a more extensive use of hydraulic mechanisms in machine tools; increased attention to lubrication; and provisions to insure higher accuracy of work turned out, and greater ease and convenience of operation. Experience with tungsten carbide cutting tools is related and some of the new materials available, such as high-test cast iron, improved alloys, and stainless and nitrided steels are briefly dealt with, as is also progressive standardization work in machine-shop practice. It is pointed out that some progress has been made in improving management and particularly cost methods and that management had evidently accepted the soundness of the modernization principle.

POWER REQUIRED TO DRILL CAST IRON AND STEEL. By O. W. Boston and C. J. Oxford. [Paper No. MSP-52-2]

This paper presents the results of drilling tests on cast iron and steel. Drills ranging in diameter from $1/2$ to $1\,1/2$ in. of the standard twist-drill type were used. The drills were considered sharp in all tests. A coolant consisting of one part of soluble oil and 16 parts of water was used in all tests. The materials cut consisted of one regular machining cast iron and one cast iron made up of 20 per cent charcoal pig iron, together with 17 steels of a wide variety of chemical analyses, which were selected to cover the steels commonly used in modern manufacture.

Data as to drilling torque, thrust, computed horsepower at the drill point, and net horsepower supplied to the machine as measured on a recording wattmeter are given under two headings: commercial tests and special tests. All commercial tests were run at a peripheral speed of the drill of approximately 60 ft. per min. The feed for each drill size was as near to those given in the usual commercial-drilling table as the change gears available would permit.

Special tests were run on various cast irons and steels so that the influence of the speed, feed, and drill diameter could be determined, in order that the results of the commercial-drilling tests could be extended to cover any other conditions of drilling for each material. It was found from these special tests that the thrust for both cast iron and steel increased in direct proportion to the drill diameter d; that the torque increased in proportion to d^2 for cast iron and $d^{1.8}$ for steel. The thrust increased with an increase in feed f, but at a rate as slow as $f^{0.6}$ for both cast iron and steel. The torque increased as $f^{0.6}$ for cast iron, but $f^{0.78}$ for steel. It was found that the torque and thrust remained practically constant over the whole range of speeds covered from 74 to 441 r.p.m. for each drill size and feed.

An attempt made to correlate the hardness values of the materials determined by various hardness testers with the results obtained from the drilling tests showed that no satisfactory relation exists between these properties.

THE PRESENT STATUS OF CEMENTED TUNGSTEN CARBIDE TOOLS AND DIES. By Zay Jeffries. [Paper No. MSP-52-3]

After discussing the origin, production, and properties of cemented tungsten carbide, the author takes up the matter of utilizing the material in cutting tools. Its adaptability for wire-drawing and blanking dies is brought out, as well as its ability to cut hitherto unmachinable materials such as glass, porcelain, asbestos products, etc. Data are given on the life of cemented tungsten carbide tools as compared with older types of tools on a varied assortment of machining jobs, following which the author concludes with a brief consideration of the commercial situation and the future possibilities of the material.

WHAT INFORMATION DOES THE MACHINE-TOOL BUYER NEED FROM THE MACHINE-TOOL SALESMAN? By George T. Trundle, Jr. [Paper No. MSP-52-4]

The author first enumerates the matters regarding which the buyer needs information in buying equipment. He then discusses the service and advice needed by the buyer, following which he deals respectively with the substituting of rebuilt machines for new ones, when machines should be replaced, and the desirability of a manufacturer's maintaining a liquid depreciation reserve for the replacement of equipment.

OIL AND GAS POWER PAPERS

STANDARDIZATION OF ENGINE RATINGS. By H. E. Brelsford. [Paper No. OGP-51-8]

After a discussion of the factors involved, the author proposes the following ratings for moderate-speed Diesel engines (under 800 r.p.m.). The ratings offered, based on mean indicated pressures, are to be considered as maximum.

Four-cycle air-injection engine, 105 lb. max. indicated pressure. Four-cycle mechanical-injection engine, 100 lb. max. indicated pressure. Two-cycle air-injection engine with excess scavenging air, 95 lb. Two-cycle mechanical-injection engine with excess scavenging air, 90 lb. Two-cycle mechanical-injection engine with 1 to 1 ratio or less scavenging air, 70 lb.

The author also recommends that entirely apart from the question of standard ratings of any engines, the corrections for altitude up to 10,000 ft. be based on the effect of barometric pressure on the indicated output at sea level, excepting, however, that no correction be made from sea level to 2000 ft., and that the correction curve of 2000 to 5000 ft. be faired into the theoretical at 5000 ft.

SOME RESULTS OF OIL-SPRAY RESEARCH. By K. J. De Juhasz. [Paper No. OGP-51-9]

After enumerating the objectives in such research to develop the solid-injection oil engine, the author presents the nomenclature employed in discussing oil-spray characteristics. He then describes the facilities for oil-spray research at Pennsylvania State College, and lists the characteristics investigated during 1929. Appendixes deal with the theory underlying the recording pendulum used in determining the momentum of the oil spray, and with the error of the method used in measuring the instantaneous spray velocity.

HIGH-SPEED OIL-ENGINE PUMPS AND INJECTION VALVES. By John L. Goldthwaite. [Paper No. OGP-51-10]

Unable to find reliable data on high-speed injection valves and pumps for Diesel-engine manufacture, the author made a study of the problem, and his findings are given as an elementary treatise to clear the many points of trouble. As a practical solution of the injection problem, he makes a compact unit of the entire drive, the admission valves, and the controls. He uses the constant-pressure system, groups the admission valves for convenience, and pipes them to heavily loaded automatic injectors.

COMBUSTION IN HIGH-SPEED OIL ENGINES. By William F. Joachim. [Paper No. OGP-51-11]

The paper discusses some of the more important physical and chemical aspects of the combustion problems of the high-speed Diesel engine of today from the oil-spray and oil-mixture standpoints. Of considerable importance also are other aspects of the general combustion problem from the standpoints of detail fuel-injection methods, rates of injection, processes of atomization, spray-particle mass distribution, and cylinder design and com-

bustion-air movement. While a near approach to the high thermal efficiencies indicated by theory may not be at once completely reached in high-speed oil engines, rapid advances in the art of combustion control are being made.

HIGH-SPEED DIESEL-ENGINE DESIGN. By Otto Nonnenbruch. [Paper No. OGP-51-12]

The author first gives a table comprising data on examples of internal-combustion engines ranging from the heaviest to the lightest. These data are: number of cylinders, bore and stroke, piston displacement, r.p.m., piston speed, mean effective pressure, horsepower, weight, wt–hp. ratio, and wt–piston displacement ratio. Defining the high-speed Diesel as one running at 1000 r.p.m. or over, he gives a similar table dealing with 12 engines of well-known makes. In a third table he compares the dimensions and construction of various engine parts, as well as such matters as materials used, lubrication, fuel injection, etc. These various details are discussed in the surrounding text.

RAILROAD PAPERS

PROGRESS IN RAILROAD MECHANICAL ENGINEERING. [Paper No. RR-52-1]

This report briefly surveys the technical developments of 1929 in the locomotive field, giving brief particulars of the various high-pressure, turbine, and internal-combustion locomotives that have been built during the period in question. Mention is made of the draft-gear tests of the A.R.A. on freight cars, and of the extension of the use of special refrigerating systems.

LOCOMOTIVE AUXILIARY POWER MEDIUMS. By George W. Armstrong. [Paper No. RR-52-2]

In this paper the author describes the Bethlehem auxiliary locomotive and gives some test results. A self-contained power truck is provided which can replace one of the regular tender trucks, either a front or rear truck of the locomotive, and in some cases to replace both trucks. Ordinarily the rear-truck installation is recommended as it facilitates removal for inspection and maintenance.

HEAT TRANSFER IN THE LOCOMOTIVE SUPERHEATER. By Lawford H. Fry. [Paper No. RR-52-3]

The author's method for calculating heat transfer in locomotive flues is applied to determine the heat transfer in the superheater flues and tubes. It is applied to three sets of experimental data obtained from two locomotives on the Altoona locomotive test plant. In each case the firebox temperature and the rate of flow of the gases of combustion through the flues are taken as points of departure. The Fry method is used to calculate the temperature drop along the evaporative flues and along the superheater flues, and the transfer of heat to the evaporative surface of the flues containing the superheater pipes and to the superheater pipes. The results of the calculations indicated are shown in tabular form in comparison with the observed results.

DESIGN AND APPLICATION OF RAIL MOTOR CARS. By Charles O. Guernsey. [Paper No. RR-52-4a]

The rail car is capable of performing certain services to better advantage than motive power of any other current type. It is not a competitor of the locomotive in the locomotive's proper field. It is capable of performing services within its scope at a cost and with an availability and reliability at least equal to other railroad equipment.

Satisfactory operation depends on correct design, correct application, proper handling by the operators, and intelligent and thorough maintenance. The maintenance should be in the hands of an intelligent, properly trained supervisor, who has sufficient authority to handle his work without clearing details through other officials. The design must be such that all wearing parts are renewable, at the minimum of expense, and with a minimum of time out of service. The exhaust valves are apt to require attention more frequently than other features of the engine, therefore the design should be such as to give maximum exhaust-valve life. Twin exhaust valves have been found desirable for this purpose.

Cooling systems must be designed to operate effectively regardless of car speed or direction. Transmission equipment should be capable of delivering to the rails the maximum possible percentage of engine power throughout the range of car speeds, at least to 60 m.p.h. The parasites and accessories can be handled to best advantage by the use of a small separate power plant. Cars of current designs are proving their worth in millions of miles of service annually on many different railroads in various parts of the world. The rail car is generally accepted as a proved tool for the reduction of operating costs and improvement of service within its field.

SYMPOSIUM ON THE MAINTENANCE OF RAIL MOTOR CARS. [Paper No. RR-52-4b]

Gas Rail Cars on the New Haven Railroad. By E. O. Whitfield. This paper outlines various rail-car problems, pertaining particularly to organization and maintenance, that have been dealt with on the New Haven railroad over a period of approximately eight years. As would naturally be expected, a vast amount of pioneer work has been necessary to bring rail-car internal-combustion and transmission equipment up to its present state of efficiency and reliability.

Rail Cars on the Union Pacific System. By W. J. Wilson. The Union Pacific in the course of its 20 years' operation of rail cars has developed servicing and repair methods to which the author briefly refers. He discusses in some detail troubles which have been met and overcome, together with special phases in connection with maintenance.

HIGH-PRESSURE-LOCOMOTIVE DEVELOPMENTS. By A. E. Stuebing. [Paper No. RR-52-5]

This paper discusses two types of high-pressure locomotives recently built, the Loeffler type and the Winterthur locomotive. The former is an express locomotive of about 2500 hp. with a pressure of 1470 lb. per sq. in. and the latter of about 1200 hp. with a boiler pressure of 850 lb. per sq. in. The Loeffler locomotive is expected to result in a fuel saving of from 40 to 45 per cent compared with modern superheated locomotives.

NOTE: Those who have not registered in the A.S.M.E. Machine-Shop Practice, Oil and Gas Power, and Railroad Divisions whose papers are abstracted on this and the previous page, and who desire copies of any of these papers, may obtain them by using the form given below.

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ABRASIVE MATERIALS

Grain Size. Is Close Grain Size Essential? H. R. Power. Abrasive Industry, vol. 11, no. 6, June 1930, pp. 46 and 48. Description of influence of grain size and means for separating different sizes; use of silk bolting cloth and screening troubles; commercial experience does not favor extremely closely graded product.

AERIAL PHOTOGRAPHY

Use of. Utilization of Aerial Photography (L'Exploitation de la photographie aérienne), L. Poncelet. Conquete de l'Air (Paris), vol. 26, no. 5, May 1930, pp. 387–394, 13 figs. Notes on fundamental optics and description of apparatus for transforming aerial photographs, and of cartographic machines built by Aérotopographe G.m.b.H., C. Zeiss., Hugershoff, H. Wild, and Nistri.

AERIAL TRANSPORTATION

Boeing System. Day and Night Transcontinental Service. Airway Age, vol. 11, no. 5, May 1930, pp. 658–659, 2 figs. Notes on equipment and operation of San Francisco-Chicago line; table compares train and plane schedules; plane weighs 8¾ tons when fully loaded with 18 passengers, two pilots, steward and their baggage, and powered with three Pratt & Whitney 525-hp. nine-cylinder radial air-cooled Hornet engines; cruising speed of 115 m.p.h.; high speed of 138 m.p.h.

Radio Communication. Voice or Code in Aircraft Radio, W. G. Logue. Aviation, vol. 28, no. 25, June 21, 1930, pp. 1213–1216. Advantages of telegraph apparatus are pointed out; performance and operation of telephone and telegraph equipment are discussed; radio telephone apparatus in plane now costs more than three times as much as two-way telegraph apparatus capable of working same or greater distances, and radio telephone ground transmitters now cost from one-third to one-fourth more than ground telegraph equipment; data on weight are given.

AERODYNAMICS

Measuring Air Pressure. Air Force (Pressure) Measurements With Wings, Leading Edge Forming Angle With Air Current (Luftkraftmessungen an schraeg angeblasenen Traffluegeln), F. Budig. Zeit. fuer Flugtechnik und Motorluftschiffahrt (Munich), vol. 21; no. 10, May 28, 1930, pp. 245–249, 10 figs. Description of aerodynamical experiments on sailboat, and with wing mounted on shore; center of pressure is shifted forward if air hits leading edge at angle; graphs show pressure distribution; application of conclusions to spinning, etc.

AERONAUTICAL EDUCATION

Ground Schools. American Ground Schools, M. F. Eddy. West. Flying, vol. 7, no. 6, June 1930, pp. 50–53, and 130, 3 figs. Discussion of ground-school organization and operation; notes on instructors and students; class schedules.

AIR CONDITIONING

Research. The Possibilities of Conditioning Air for Comfort, L. L. Lewis. Ice and Refrig., vol. 78, no. 6, June 1930, pp. 490–492, 6 figs. See also Refrigeration, vol. 47, no. 6, June 1930, pp. 46 and 48. Results of research of American Society of Heating and Ventilating Engineers; use of air conditioning in theaters, department stores, and hotels; waste heat of thermodynamic cycle; classification of heat; first attempt at air conditioning. Paper read before Am. Inst. of Refrig.

AIRPLANE ENGINES

Diesel. The Packard Aviation Diesel Engine, L. M. Woolson. Diesel Power, vol. 8, no. 5, May 1930, pp. 254–257, 6 figs. Discussion of design and constructional features of Packard Diesel aircraft engine, which is radial air-cooled type having nine cylinders with bore of $4^{13}/_{16}$ in. and stroke of 6 in. giving displacement of 980 cu. in.; 225 hp. rating at 1900 r.p.m., and weighing 2.26 lb. per rated horsepower; starting and stopping. See also Engineering Index 1929, p. 55.

Research of the National Advisory Committee for Aeronautics on Aircraft Diesel Engines, C. Kemper. Am. Soc. Mech. Engrs.—Advance Paper for mtg., June 12 to 14, 1930, 7 pp. Résumé of progress in investigation of fundameatal factors controlling injection and combustion: drop size, rate of injection, spray dispersion and distribution, temperature, and air density and turbulence. Bibliography.

Design. Airplane Engine Development and Operating Reliability, R. Chilton. Soc. Automotive Engrs.—Jl., vol. 26, no. 6, June 1930, pp. 771–781, 3 figs. Practically all parts failures in engines are from fatigue originating at small local defects in material or from resonant vibrations which carry stresses beyond safe fatigue limit of material; notes on performance and supercharging; means of measuring torsional vibration; valve springs and valves.

Maintenance and Repair. Maintenance of Aircraft Engines and Accessories, H. C. Downey. Airway Age, vol. 11, no. 5, May 1930, pp. 654–656, 5 figs. Outline of methods and problems in overhaul at Panama Air Depot, France Field, Canal Zone; notes on wear of principal parts and on method of boring Curtiss bearings; data for setting valves on D-12 engines. (To be concluded.)

Renault. Renault 95-Hp. 4-Cylinder In-Line Engine (Le Moteur Renault 95 CV 4 cylinders en ligne), J. Cailleux. Air (Paris), vol. 12, no. 254, June 1930, pp. 17–18, 4 figs. Description of air-cooled engine with 115 mm. bore and 140 mm. stroke, 95 hp. at 2000 r.p.m.; weight complete 138 kgs.; sketches show details of design.

Supercharging. The Supercharging and Compounding of Aero Engines, H. R. Ricardo. Engineering (Lond.), vol. 129, no. 3360, June 6, 1930, pp. 738–739. Editorial review of Wilbur lecture read before Royal Aeronautical Society; to obtain substantial increase of power at ground level by means of supercharging, poppet type of exhaust valve must be abandoned; in its stead author suggests use of single-sleeve valve; compounding on these lines should result in material improvement in economy as well as in reduction in weight.

Testing. Engine Testing Laboratory, C. M. Young. Aviation Eng., vol. 3, no. 5, May 1930, pp. 7–9, 3 figs. Description of equipment and procedure used by Dept. of Commerce, Aeronautics Branch for type-testing aircraft engines; specifications of engine requirements call for 50-hr. endurance tests.

Throttling. Aircraft-Engine Wear Elimination by Throttling (Motorschonung durch Drosseln), Schatzke. Zeit. fuer Flugtechnik und Motorluftschiffahrt (Munich), vol. 21, no. 7, Apr. 14, 1930, pp. 164–175, 21 figs.; see brief translated abstract in Automotive Abstracts, vol. 8, no. 6, June 20, 1930, p. 104. Throttling has strong effect on engine life and decrease of strains in engines has definite effect; author recognizes costs involved in research method, and suggests temporary method which amounts to using of similar aircraft engines now in operation under constant conditions for each engine; varying conditions assigned to each plane will show effect upon engine wear of each condition.

AIRPLANE MATERIALS

A.S.T.M. Papers. Aviation Materials—Reviewed in Broad Symposium. Iron Age, vol. 126, no. 1, July 3, 1930, pp. 19–22 and 60. Brief review of papers presented at convention of American Society for Testing Materials at Atlantic City chiefly on metals in aircraft construction; notes on scope of aircraft industry.

Tubing. Petrol-Flex Tubing, W. C. Blyth. Mech. World (Manchester), vol. 87, no. 2269, June 27, 1930, p. 604, 2 figs. Petro-flex tubing is flexible type of tubing almost universally used on aircraft work for conveying gasoline from various tanks to engine; it is built up of simple materials, consisting of internal armor of tinned copper wire, round which is wound longitudinal strip of fabric, first layer of which is rubber-coated, succeeding layers being impregnated with paint.

AIRPLANE PROPELLERS

Efficiency. Influence of Hull Upon Efficiency of Propeller (Der Einfluss des Flugwerks auf den Vortriebswirkungsgrad der Luftschraube), F. Weinig. Zeit. fuer Flugtechnik und Motorluftschiffahrt (Munich) vol. 21, no. 8, Apr. 28, 1930, pp. 196–200, 3 figs.; see also brief translated abstract in Mar. Engr. and Motorship Bldr. (Lond.), vol. 53, no. 633, June 1930, p. 242. Author,

while primarily dealing with problem of airscrew, develops theoretical investigation directly applicable to marine problem of influence of hull upon propulsive efficiency; case treated is that of tractor propeller.

Vibrations. Contribution to the Theory of Propeller Vibrations, F. Liebers. Nat. Advisory Committee for Aeronautics—Tech. Memorandum, no. 568, June 1930, 23 pp., 5 figs. Calculation of torsional frequencies of revolving bars with allowance for air forces; bending frequencies of revolving straight and tapered bars; Rayleigh's principle of variation; error estimation and accuracy of results; application of theory to screw propellers for airplanes. Translated from Zeit. fuer Technische Physik, vol. 10, 1929.

AIRPLANES

Autogiros. See AUTOGIROS.

Ailerons. Effect of Variation of Chord and Span of Ailerons on Rolling and Yawing Moments at Several Angles of Pitch, R. H. Heald, D. H. Strother, and B. H. Monish. Nat. Advisory Committee for Aeronautics—Report, no. 343, 27 pp., 47 figs. Investigation of rolling and yawing movements due to ailerons of various chords and spans on two airfoils having Clark Y and U. S. A. 27 wing sections, in 10-ft. wind tunnel of Bureau of Standards on wing models of 60-in. span and 10-in. chord; measurements were made at various angles of pitch but at zero angle of roll and yaw, wing chord being set at angle of plus 4 deg. to fuselage axis.

Autorotation of Wings. A Possible Method for Preventing the Autorotation of Airplane Wings, O. Schrenk. Nat. Advisory Committee for Aeronautics, no. 569, June 1930, 6 pp., 9 figs. Autorotation tests with model of normal wing provided with pair of symmetrical slots on suction side connected with each other inside wing; arrangement of apparatus is shown. Translated from Zeit. fuer Flugtechnik und Motorluftschiffahrt, Nov. 14, 1929, previously indexed.

Design. Effect of Rigid Support on Rods Stressed for Buckling in Airplane Frame Works (Einspannwirkung bei Knickstaeben in Flugzeug-Fachwerken), A. Teichmann. Zeit. fuer Flugtechnik und Motorluftschiffahrt (Munich), vol. 21, no. 10, May 28, 1930, pp. 249–254. Discussion of previous literature; buckling formulas for simple rod combinations with numerical examples. Bibliography.

Practical Use of Logarithmic Polar for Calculation of Airplane Performance (Utilisation pratique de la Polaire-Logarithmique pour le calcul des performances des avions), G. Bilbault. Technique Aéronautique (Paris), vol. 21, no. 100, and 101, Feb. 15, 1930, pp. 35–41, and Mar. 15, pp. 50–59, 4 figs. Description of method indicated by Eiffel; combined use of characteristic curves of plane gives for certain altitude speed power, r.p.m. of engine, and efficiency of propeller; graphical procedure discussed and illustrated.

Drag Testing. Full Scale Drag Tests on Various Parts of Fairchild (FC-2W2) Cabin Monoplane, W. H. Herrnstein, Jr. Nat. Advisory Committee for Aeronautics—Tech. Notes, no. 340, May 1930, 14 pp., 17 figs. Drag due to various parts of Fairchild (FC-2W2) cabin monoplane was measured at air speeds varying from 50 to 100 m.p.h., in 20-ft. propeller research tunnel of National Adivsory Committee for Aeronautics; it was found that largest drag was due to radial air-cooled engine.

Ice Formation. Refrigerated Wind-Tunnel Tests on Surface Coatings for Preventing Ice Formation, M. Knight and W. C. Clay. Nat. Advisory Committee for Aeronautics—Tech. Notes, no. 339, May 1930, 21 pp., 14 figs. Investigation conducted in Refrigerated Wind Tunnel at Langley Memorial Aeronautical Laboratory, Langley Field, to determine effectiveness of various surface coatings as means for preventing ice formation on aircraft in flight; hardened karo-syrup solution was found to be most effective.

AIRPORTS

Beacons. The Winnipeg Airway Beacon. Engineering (Lond.), vol. 129, no. 3359, May 30, 1930, p. 701. In connection with night-flying operations, what is believed to be largest air beacon in British-Empire and third largest in world, was augurated on Mar. 3 last; it is erected on roof of large new department store of Hudson Bay Co. at Winnipeg; light provided is about 200 ft. from ground, and main structure of beacon is surmounted by 24-in. Novalux directional beacon; light is provided by special 1000-watt lamp operating on 115 volts, and giving 1,712,000 beam candle power.

A Tuned-Reed Course Indicator for the Four- and Twelve-Course Aircraft Radio Range, F. W. Dunmore. Inst. Radio Engrs.—Proc., vol. 18, no. 6, June 1930, pp. 963–982, 15 figs. For 12-course radio range system, in which three modulation frequencies are used, type of reed indicator has been developed to indicate when aircraft is on any one of 12 courses, and if off, approximately how many degrees and whether to right or left.

Costs. Unit Prices From Current Construction Bids. Eng. News-Rec., vol. 104, no. 20, May 15, 1930, pp. 829–830, 3 figs. New York airport bids on nine structural items; timber supports for cotton bales, New Orleans; concrete paving in Maryland; enlarging Morena rock fill dam and spillway for San Diego, details of spillway gates.

Runways Surfacing. Oil Separators Runways at Valley Stream, W. S. Bartlett. Airports, vol. 4, no. 6, June 1930, pp. 23–25, 3 figs. Discussion of construction methods and materials used by Stone & Webster Engineering Corp.; in surfacing Curtis-Wright airport at Valley Stream; data on oil application and drainage.

ALLOY STEEL

Anti-Corrosive. Corrosion Resistant Steels Solve Many Problems of Designers, H. A. De Fries. Machine Design, vol. 2, no. 5, May 1930, pp. 23–25, 3 figs. Notes on uses of non-corrosive chromium and chromium-nickel alloys; tables give analysis and properties of KM-1 and KA-2 alloys; data on heat treatment are given.

Mechanical Properties. The Relative Merits of Some Different Alloy Steels With Respect to Certain Mechanical Properties, B. Stoughton and W. E. Harvey. Am. Soc. Testing Matls.—Advance Paper, no. 35, June 23–27, 1930, 16 pp. Taking as basis about 50 binary or ternary alloy steels whose chemical analysis and mechanical properties have been published, 1800 numerical calculations were made grading steels in order of their relative standing according to numerical value of product of some function of their strength multiplied by function of their ductility or according to values of strength multiplied by Izod impact value.

ALLOYS

Chromium-Nickel. See CHROMIUM-NICKEL ALLOYS.

Anti-Corrosive. Heat and Corrosion Resisting Materials, H. D. Phillips. Blast Furnace and Steel Plant, vol. 18, no. 7, July 1930, pp. 1143–1147, 9 figs. Brief notes on properties and characteristics of metals and alloys that are found in modern equipment.

ALUMINUM

Soldering. Soldering Aluminum, P. N. Emigh. Power Plant Eng., vol. 34, no. 11, June 1, 1930, pp. 642–643, 4 figs. Practical discussion of special flux, correct solder, and methods employed.

Spinning. Aluminum Spinning Practice, R. J. Anderson. Metal Stampings, vol. 3, no. 6, June 1930, pp. 513–518, 3 figs. Operations involved in spinning of aluminum; equipment and tools required; auxiliary operations of necking, grooving, bulging, and trimming parts drawn in presses.

Welding. Fusion Welding of Aluminum. Am. Mach., vol. 72, no. 22, May 29, 1930, p. 885, 5 figs. Sketches explain characteristics of oxyacetylene flames; table gives approximate size of tips and relative gas pressures used in welding aluminum of different thicknesses; use and composition of fluxes and rods is described.

AUTOGIROS

Development. The Autogiro. E. D. Rice. Engrs. and Eng., vol. 47, no. 2, Feb. 1930, pp. 25–28, 1 fig. Development, results of tests, and design features.

AUTOMOBILE ENGINES

Design. A Three-Cylinder Two-Stroke. Autocar (Lond.), vol. 64, no. 1805, June 6, 1930, p. 1130, 3 figs. Notes on design and performance of Barrington engine; bore of 68 mm. and stroke of 70 mm.; crankcase compression; gas distribution by means of ports controlled by deflector head type of piston.

AUTOMOBILES

Front Wheel Drive. Automobile and Front-Wheel Traction (L'Automobile et la traction avant), J. A. Gregoire. Technique Automobile et Aérienne (Paris), vol. 21, no. 149, pp. 46–53, 20 figs. Description of design and kinematics of principal types of universal; joints particularly of Tracta model; sketches show constructional details; Tracta, Weiss, and Parville are only joints providing constant angular velocity.

Tracta Automobile (La Tracta), R. Charles-Faroux. Vie Automobile (Paris), vol. 26, no. 944, Apr. 25, 1930, pp. 139–142, 8 figs. Description of front-wheel drive car; sketches show details of universal joint which at angle of 50 deg. transmits constant angular velocity.

Riding Qualities. Riding Qualities Analyzed From Psychological View, A. F. Denham. Automotive Industries, vol. 62, no. 23, June 7, 1930, pp. 867–869, 10 figs. Abstracts of papers on riding qualities and fatiguing effect on human system presented before Society of Automotive Engineers, by F. A. Moss on bodily steadiness as index of riding comfort, G. C. Brandenburg and A. Swope on psychology of riding quality, and F. W. Pawlowski on wind resistance.

B

BELTS AND BELTING

Horsepower. Belt Horsepower Charts. Product Eng., vol. 1, no. 5, May 1930, pp. 249–250, 2 figs. Chart shows, graphically various quantities in belt or chain transmission.

BOILER PLATES

Cracking. Intercrystalline Cracking in Steam Boilers Cause of Many Boiler Explosions, F. G. Straus. Iron and Coal Trades Rev. (Lond.), vol. 120, no. 3251, June 20, 1930, p. 988. Use of microscope in determining whether crack is intercrystalline or transcrystalline; cracks, however small, are cause of enormous amount of loss to industry; suggested rule of A.S.M.E. for care of boilers. Paper read before World Power Conference, Berlin.

Fractures in Boiler Metal, A. E. White and R. Schneidewind. Am. Soc. of Mech. Engrs.—Advance Paper, for mtg. June 9–12, 1930, 19 pp., 63 figs. Examinations, which were to large extent metallographic in nature, have led to some generalizations and classification of cracks and fractures as related to causes of failures; types of failure and their metallographic characteristics; material presented consists of short review of literature on boiler-metal failures, detailed description of fractures in boiler metal due to known causes, and description of actual failures in service.

Embrittlement. Recent Developments in Embrittlement Research, F. G. Straub. Power Plant Eng., vol. 34, no. 12, June 15, 1930, pp. 686–687. Sulphate prevents embrittlement only when it is present in amounts which will cause solid sodium sulphate to form in seams; studies at pressures up to 1300 lb. indicate that present 3 to 1 ratio recommended by A.S.M.E. code will be safe for practically all boiler pressures; why boilers that do not have sulphate ratios do not crack.

Temperature Effect. Strength of Boiler Plates at Elevated Temperatures, With Special Regard to Relation of High-Temperatures Yield Point to Tensile Strength at Room Temperature (Festigkeitseigenschaften von Kesselblechen bei erhoehten Temperaturen), F. Koeber and A. Pomp. Mitteilungen aus dem Kaiser-Wilhelm-Institut fuer Eisenforschung (Duesseldorf), vol. 12, no. 3, 1930, pp. 13–22, 19 figs. Determination of 0.05, 0.1, and 0.2 limits and of tensile strength; elongation and shrinkage at 20, 300, 400, 450, and 500 deg. on 12 different boiler plates.

BOILERS

Feedwater Treatment. See FEEDWATER TREATMENT.

High Pressure. The Design and Results of a 600 Lb. per Sq. In. Boiler Installation, W. Nithsdale. Mech. World (Manchester), vol. 87, nos. 2260 and 2261, Apr. 25, 1930, pp. 395–396, and May 2, pp. 407–409, 5 figs. Abstract of paper read before Instn. Mech. Engrs., previously indexed from Engineering (Lond.), Mar. 28, 1930.

Humming and Smoking. Elimination of Boiler Humming and Smoking (Beseitigung von Kesselbrummen und Rauchen), W. Weck. Zeit. des Bayerischen Vereins (Munich), vol. 34, no. 10, May 31, 1930, pp. 149–151. Scientific measures for overcoming humming and smoking have been developed and successfully applied; details of Weck air regulator supplemented by flaps and walls for improving air distribution.

Lignite Fired. Boiler Furnaces for Lignite Firing (Dampfkessel-Feuerung fuer Braunkohle), Berner. Waerme (Berlin), vol. 53, nos. 24 and 26, June 14, 1930, pp. 455–462, and June 28, pp. 510–513, 16 figs. Efficiency and performance in relation to quality of coal; general notes on furnace losses; design of grate; efficiency limits with lignite firing; relation of efficiency limit to quality of coal; means of increasing furnace efficiency; new processes with gas and coke return circuit; pulverized-fuel supplementary firing.

Load Fluctuations. Causes and Effects of Load Fluctuations in Boiler Operation (Ursachen und Folgen der Belastungsschwankungen im Kesselbetrieb), E. Praetorius. Zeit. des Bayerischen Revisions Vereins (Munich), vol. 34, nos. 7 and 9, Apr. 15, 1930, pp. 91–93, and May 15,

pp. 126–128, 10 figs. Among causes of fluctuation are day and night changes, seasonal changes, influence of weather, turning off and on of steam-consuming equipment; disadvantages of load fluctuation are enumerated; preventive measures include elastic firing, heat storage, and similar devices.

Oil Burning. Comparative Performance of a Large Boiler Using Oil and Natural-Gas Fuels, F. G. Philo. Am. Soc. Mech. Engrs.—Advance Paper, for mtg. June 9–12, 1930, 11 pp., 31 figs. Boiler tested was Babcock and Wilcox crossdrum, straight-tube type with interdeck superheater; furnace was completely inclosed by Bailey type water-cooled walls; Babcock and Wilcox air heater was of tubular construction; Peabody combination oil and gas burners were used; highest rate of output at which boiler was tested was 450,751 lb. of steam per hour, which represented operation of 3416-hp. boiler at 413.2 per cent of rating.

Pulverized-Coal Fired. Comparative Performance of a Pulverized-Coal-Fired Boiler Using Bin System and Unit System of Firing, A. E. Grunert. Am. Soc. of Mech. Engrs.—Advance Paper, for mtg. June 9–12, 14 pp., 8 figs. Operation of two systems is compared in three ways, first, on evaporative-test basis; second, on basis of actual overall performance; and, third, on operating-cost basis; record of pertinent experiences with both systems is given; owing to specific nature of program, no general conclusions are given, and there is no intention to contribute to controversial phase of the problems presented by the subject of the paper.

Testing. Tests of the Resistance to Repeated Pressure of Forged, Riveted, and Welded Boiler Shells, H. F. Moore. Am. Soc. Mech. Engrs.—Advance Paper, no. 15, for mtg. June 9–12, 1930, 6 pp., 7 figs. Comparative tests on standard A.S.M.E. riveted drum, manganese-steel riveted drum, forged seamless-steel shell, two-forge-and-hammer-welded sheels, and eight fusion-welded (metallic-arc) shells, well above allowable working pressure; under repeated stress properly made welded joints are stronger than plates themselves when weakened by stress raisers such as small holes or surface defects; data on strength of drum heads.

Wood Waste Fired. Boiler Settings for Burning Refuse Wood, C. S. Gladden. Am. Soc. of Mech. Engrs.—Advance Paper for mtg., June 9–12, 1930, 13 pp., 14 figs. Some recent developments in design of boiler furnaces for burning green or wet refuse wood; experiences influencing development of furnaces for burning dry refuse wood; factors influencing design of wood-burning furnaces.

BOLTS AND NUTS

Manufacture. Bolts, Nuts, and Rivets From Pacific Coast Steel, C. A. Handschin. West. Machy. World, vol. 21, no. 5, May 1930, pp. 173–178, 13 figs. Description of manufacturing process, equipment and operations at San Francisco plant of Pacific Coast Steel Corp.; production capacity is 1500 tons per month of bolts, nuts, rivets, cap and set screws, railroad track bolts and spikes, and special forgings; bolt and nut department requires 2500 tons of raw material per month.

BONUS SYSTEMS

In Medium-Sized Shops. Group Bonus in a Medium-Sized Shop Brings High Wages—Low Costs, N. M. Perris. Factory and Indus. Mgmt., vol. 80, no. 1, July 1930, pp. 47–49, 1 fig. Explanation of how group bonus systems as installed in certain departments of paper-box plant of medium size resulted in increase in output per machine hour of 38 per cent; labor costs are reduced approximately 30 per cent, and at same time individual employee was able to earn 22 per cent more than he did under preceding individual bonus plan.

C

CARBON DIOXIDE

Refrigerating Systems. Cooling With Carbon Dioxide, A. N. Changler. Heat. Piping and Air Conditioning, vol. 2, no. 7, July 1930, pp. 572–574, 5 figs. Discussion of equipment layout of carbon-dioxide systems for air conditioning theaters, department stores, or office buildings; carbon-dioxide condensers; carbon-dioxide receiver and pipe connections; layout of carbon-dioxide system arranged for single-effect operation; water-cooling apparatus.

CAST IRON

Heat Treatment. Heat Treatment of Cylinder and Alloy Irons, F. J. Walls and A. Hartwell, Jr. Fuels and Furnaces, vol. 8, no. 7, July 1930, pp. 969–971, 7 figs. Discussion of relief of stresses and physical changes in cylinder irons with various heat treatments; some effects of heat treatment on chromium-molybdenum and chromium-nickel-manganese cast irons. Abstract of paper presented before Am. Foundrymen's Assn.

Testing. The Effect of Melting Conditions on the Microstructure and Mechanical Strengths of Grey Cast Irons Containing Various Amounts of Carbon and Silicon, A. L. Norbury and E. Morgan. Iron and Coal Trades Rev. (Lond.), vol. 120, no. 3245, May 9, 1930, p. 758. Paper read before Iron and Steel Institute, previously indexed from Advance Paper, May 1930.

CHROMIUM-NICKEL ALLOYS

High Temperatures. Alloys for High Temperatures, W. Rosenhain and C. H. M. Jenkins. Engineer (Lond.), vol. 149, no. 3879, May 16, 1930, pp. 538–539. Discussion of paper read before Iron and Steel Inst., previously indexed from advance paper. See also discussion in Engineering (Lond.), vol. 129, no. 3357, May 16, 1930.

Alloys for Use at High Temperatures, W. Rosenhain and C. H. M. Jenkins. Iron and Coal Trades Rev. (Lond.), vol. 120, no. 3246, May 16, 1930, pp. 800–804. Paper read before Iron and Steel Institute, previously indexed from Advance Paper May 1930.

CHROMIUM PLATING

Value of. The Value of Deposited Chromium as a Corrosion Preventative, L. Wright. Chem. and Industry (Lond.), vol. 49, no. 23, June 6, 1930, p. 473. Main developments in chromium plating during last four years have been realization of limitations of deposited chromium and exploration of its uses as engineering asset dependent upon its physical properties rather than its chemical.

COAL

Briquetting. Coal Briquetting Without Binder (Zur Frage der Brikettierung von Steinkohlenstaub ohne Bindemittel), R. Uloth and W. Swietoslawski. Zeit. des Oberschlesischen Berg-u. Huettenmaennichen Vereins zu Katowice (Katowice), vol. 69, no. 5, May 1930, pp. 244–254, 6 figs. Discussion of possibility of coal briquetting without binder; author contends that laboratory method developed by Swietoslawski and assistants is unsuitable in practice but method developed by M. Dunkel may be used; W. Swietoslawski answers, defending his work. Bibliography.

Handling. See STEAM POWER PLANTS.

Preparation. Fitting Preparation to Meet Market Demands, J. B. Morrow. Coal Age, vol. 35, no. 6, June 1930, pp. 362–364, and 367, 1 fig. Visual inspection on $2^1/_2$ x 4 in. or 1 x $2^1/_2$ in. sizes is not sufficiently dependable or accurate enough for control purposes; only real determinant for extraneous matter is float-and-sink test in heavy characteristics of coal; percentage of refuse; quality and use of final product; capacity of plant; climatic conditions; available mill site; there are many places where air methods are applicable and economical, but wet process offers lower ash and greater uniformity in market product. Abstract of paper presented before Rocky Mountain Coal Min. Inst.

Pulverizers. Air-Separation Coal-Pulverizing Plant. Engineering (Lond.), vol. 129, no. 3363, June 27, 1930, pp. 826–828, 5 figs. Plant for unit system of pulverized-coal firing embodies several novel features added subsequently to original development of mill itself on Continent; British Remma Manufacturing Co., Halifax, have introduced these improvements, outstanding feature being air-separating system, which eliminates necessity for preliminary drying of fuel and provides definite discharging action of ground coal into separating system, though mill is not air swept in accepted sense of term.

CONVEYORS

Belt. Care and Operation of Conveyor Belts and Equipment, J. W. Schaffner. Power Transmission, vol. 36, no. 5, May 1930, p. 28. Discussion of causes of poor belt elevator service; elimination of danger of static electricity. (Continuation of serial.)

Centralized Control. Intricate Conveyor System Has Centralized Controls, C. K. Pevear. Iron Trade Rev., vol. 86, no. 23, June 5, 1930, pp. 75–79, 10 figs. Description of conveyors and handling devices used in warehouse of merchandising department of Western Electric Co., Kearny, N. J.; live roller curve, sorting mechanisms, alligator switches, lowerators; cross-section showing elevations of two warehouse buildings. Paper presented at A.S.M.E. Materials Handling meeting in Chicago, Mar. 5–7.

Forge Shops. See FORGE SHOPS.

D

DIESEL ENGINES

Automotive. Diesel Engine for Motor Vehicles and Its Economy (Der Dieselmotor fuer Kraftfahrzeuge und seine Wirtschaftlichkeit), Wawrziniok. Automobiltechnische Zeit. (Berlin), vol. 33, no. 17, June 20, 1930, pp. 416–420, 4 figs. General discussion of factors controlling economy; combustion chamber design and injection principle; tables give fuel specification and data on design and performance of Diesel and carburetor engines; operating economy of M.A.N. Diesel and M.A.N. gasoline truck is compared.

The Diesel Engine as Applied to Road Transport, W. H. Goddard. World Power (Lond.), vol. 13, no. 77, May 1930, pp. 439–444, 8 figs. It is evident that Diesel engine is destined, in near future, to occupy very important place not only in Great Britain but in most parts of civilized world; full description of technical details of Diesel engine and its performance as compared with that of gasoline engine.

Design. Well-Known Marine Diesel Engine Offered for Stationary Service. Diesel Power, vol. 8, no. 5, May 1930, pp. 258–260, 4 figs. Discussion of main structural design features of stationary Diesel engine of Electric Boat Company; six-cylinder 1000-b.hp. trunk-piston airless-injection with $20^7/_8$ in. by $20^7/_8$ in. bore and stroke; rated to operate at 257 r.p.m.; fuel-injection system; curves illustrating operating characteristics.

Fuel Injection. Some Effects of Air and Fuel Oil Temperatures on Spray Penetration and Dispersion, A. G. Gelalles. Nat. Advisory Committee for Aeronautics—Tech. Notes, no. 338, May 1930, 11 pp., 6 figs. Spray records and curves plotted from records show that changed properties of air and fuel under high temperatures decreased penetration and increased dispersion of oil sprays. Bibliography.

High Speed. Injection Systems for High-Speed Diesel Engines, L. Hausfelder. Diesel Power, vol. 8, no. 6, June 1930, pp. 311–313, 2 figs. Illustrated description of design features of constant-stroke fuel pumps; port-controlled pumps. (Continuation of serial.)

Supercharging. The Compounding and Supercharging of Diesel Engines, M. Gautier. Shipbldr. (Lond.), vol. 37, no. 238, Apr. 1930, pp. 432–433. Paper presented before Association Technique Maritime et Aéronautique, indexed in Engineering Index 1929, p. 568, from Bul. Technique du Bureau Veritas, July and Aug. 1929.

Maintenance and Repair. Diesel Engine Upkeep. Power Plant Eng., vol. 34, no. 12, June 15, 1930, pp. 699–701, 5 figs. Piston upkeep is dependent upon operating conditions of other engine parts; high temperatures complicate problem; repair and upkeep methods; withdrawal and replacement. (Continuation of serial.)

E

ELECTRIC WELDING

Arc Process. Industrial Progress, H. M. French. Min. and Met., vol. 11, no. 283, July 1930, pp. 352–354, 5 figs. Metallic arc, carbon arc, atomic hydrogen arc, and shielded-arc methods are briefly described; major applications of each are noted.

ELEVATORS

Capacity. The Traffic Capacity of Elevators, G. F. Draffin. Instn. Engrs. Australia—Jl. (Sydney), vol. 2, no. 5, May 1930, pp. 164–169, 4 figs. Effect of elevators of large building on both its initial cost and its rental value is such as to warrant more careful choice of elevator ratings than is usual; method of analysis is given to enable this choice to be satisfactorily made and example is worked out; while curves and tables of design data are given, it is pointed out that accuracy of results will depend very largely on experience of designer; this experience can only be gained by continual recording and systematic tabulation of data from existing installations.

ENGINEERING EDUCATION

Teaching. Teaching in Technical Schools, H. A. Norman. Engineer (Lond.), vol. 149, no. 3883, June 13, 1930, p. 662. Editorial review of address before Association of Teachers in Technical institutions; technical colleges differ from other teaching institutions in manner which has no little effect upon their constitution; while

there are certain manifest advantages in mechanical division into years, there are also disadvantages; it would be better to recognize at early stage that some men would never profit by education carried beyond certain point; it is uneconomical to force advanced education upon them; attempt to do so hinders progress of others.

ENGINEERS

Educational Activities. The Engineer as Educator, H. S. Boardman. Mich. Engr., vol. 48, no. 1, Mar. 1930, pp. 36–41. Function of engineer as educator and qualifications which fit him for this work.

Government Activities. Engineering and the Art of Government, L. W. Wallace. Mich. Engr., vol. 48, no. 1, Mar. 1930, pp. 51–59. Part engineering is playing in activities of government is shown by review of organized engineering services in various executive departments of United States and extent of function of each.

Registration. The Registration of Engineers. Engineer (Lond.), vol. 149, no. 3881, May 30, 1930, pp. 605–606. Editorial comment on symposium of papers read before Sociètè des Ingénieurs Civils de France; it seemed to be agreed that universities should still be allowed to confer their own degrees and diplomas and those awards should qualify possessors to call themselves engineers; desire to control use of title, engineer, is largely sentimental; man who has devoted many years to his education and training does not like to be classed with engine driver and mechanic; he feels that some means of distinguishing between the highly trained and untrained should exist.

Remuneration. Who Should Pay the Engineer? J. P. Ferris. Mech. Eng., vol. 52, no. 6, June 1930, pp. 615–617. Manufacturing public is accustomed to obtaining valuable engineering services without cost; author believes that important step lies in building up by industry of consulting-engineering profession; manufacturers should include as much as possible of cost of engineering services rendered in their quotations; proposed change should benefit every one except manufacturer who has been asking for excessive engineering service without placing orders in sufficient volume to pay for it.

FEEDWATER TREATMENT

High Pressure System. Development of a High Pressure System for Boiler Water Conditioning, A. H. Markson. Combustion, vol. 1, no. 1, May 1930, pp. 45–46. Discussion by R. E. Hall of paper presented before Am. Soc. Mech. Engrs., previously indexed from Apr. 1930 issue of same journal.

Methods. Boiler Feedwater Purification Methods, H. A. Kuljian. Power Plant Eng., vol. 34, no. 11, June 1, 1930, pp. 614–616, 3 figs. Continuous and intermittent precipitation water softeners and zeolite softeners; types, methods of control, and operation.

Softening. Salt Content in Feedwater (Salzgehalt im Speisewasser), R. Klein. Waerme (Berlin), vol. 53, no. 21, May 24, 1930, pp. 377–382. Influence of salt content on brine deposit on boiler; softening of carbonate- and sulphate-rich raw water according to four different processes; brine and heat losses occurring herewith are studied and examples cited.

Study of. Protecting Boilers From Embrittlement, J. J. Brennan. Power, vol. 71, no. 23, June 10, 1930, pp. 908–910, 2 figs. Use of modified alkalinity ratio including sodium carbonate as well as sodium sulphate in numerator; study of deposits formed when sodium salts crystallize from solution is desirable, as they may form films that will protect metal from attack by caustic soda and thus act as inhibitants of embrittlement.

Treatment of Feedwater. Nat. Elec. Light Assn.—Report, no. 051, 32 pp., 32 figs. Study made to determine proper ratios for prevention of boiler-metal embrittlement; effect of acid, neutral or alkaline waters and metal stresses on cracking; method of removing oxygen from feedwater for 1300 lb. per sq. in. boilers; experience in use of continuous blow-down with heat exchangers; methods of boiler-feedwater treatment that have given good results; results of carry-over tests and methods used.

F

FLOW OF FLUIDS

Early Methods. On the Problem of Hydrodynamic Stability—Uniform Shearing Motion in a Viscous Fluid, R. V. Southwell and L. Chitty. Roy. Soc. of Lond.—Philosophical Trans. (Lond.) vol. 229, Series A, 1930, pp. 205–253. 17 figs. Review of earlier investigations, methods of Kelvin, Oseen, and Osborne Reynolds; review of available methods: (1) use of integral equation; (2) method of expansion in normal coordinates; application of method of normal coordinates (numerical calculations).

FLYWHEELS

Design. Industrial Uses of Moments of Inertia of Masses and Method of Rapid Calculation of Dimensions of Flywheels (Valutazione Industriale del Momenti D'Inerxia Dell Masse e Calcolo Rapido dei Volani), L. C. Zanetti. Industria (Milan), vol. 44, no. 9, May 15, 1930, pp. 235–240. Theoretical mathematical discussion leading to derivation of formula for design of dimensions of flywheels; tables and examples.

FORGE SHOPS

Conveyors. Conveyors Serve Trimming Presses. Iron Trade, vol. 125, no. 22, May 29, 1930, pp. 1607–1608, 2 figs. Use of belt conveyors in cold trimming department of Cleveland Hardware Co., which passed along front of 20 presses and on which 15 to 20 kinds of forgings are delivered.

FOUNDRY PRACTICE

Operation at Two Foundries. Foundry Pours 4000 Tons Monthly, J. B. Nealy. Iron Trade Rev., vol. 86, no. 21, May 22 1930, pp. 51–54, 6 figs. Description of layout, operation and equipment at two foundries of Allis-Chalmers Mfg. Co., Milwaukee; main building of foundry is 994 ft. long, 221 ft. wide; all pouring is direct from cupola to flask with crane service and ladles of 1½ to 30 tons capacity; parts molded continuously; locomotive-type sand slinger; sand conditioners.

G

GEARS AND GEARING

Design. The Use of Motion Pictures to Illustrate the Generation of Involute Gearing and Use of Motion Pictures and Polarized Light as a Method of Studying Gear Stresses, W. H. Himes and R. V. Baud. Assn. of Iron and Steel Elec. Engrs.—Proc. for Yrs. 1928–1929, pp. 673–681, 15 figs. Indexed in Engineering Index 1929, p. 873, from Iron and Steel Engr., June 1929.

Manufacture of. Gearing, Johnstone-Taylor. Mech. World (Manchester), vol. 87, no. 2262, May 9, 1930, pp. 440–442, 7 figs. Description of manufacture of various gears, operation of gear cutting tools; double helical gearing; end milling, rack cutting, and hobbing; application of double helical gears; mounting; notes on wheels and pinions; lubricating arrangements. (Continuation of serial.)

Non-Metallic. Micarta Non-Metallic Gears in the Steel Mill Industry, T. C. Roantree. Assn. of Iron and Steel Elec. Engrs.—Proc. for Yrs. 1928–1929, pp. 407–409. Indexed in Engineering Index 1928, p. 865, from Iron and Steel Engr., Oct. 1928.

Non-Uniform Rotation. Excentrically Driven Gear Arrangement (Das exzentrisch angetriebene Raeddrknie), K. Hoecken. V.D.I. Zeit. (Berlin), vol. 74, no. 16, Apr. 19, 1930, pp. 509–512, 4 figs. Theoretical investigation of mechanism for non-uniform rotation with reverse movement; formulas for dimensioning various gears; movements and velocities illustrated by graphs and diagrams.

GLASS

Manufacture. Modern Plant Glass Manufacture (Neuzeitliche Spiegelglasherstellung), L. von Reis. V.D.I. Zeit. (Berlin), vol. 74, no. 26, June 28, 1930, pp. 899–905, 27 figs. Statistical data on consumption of plate glass in Europe and America; comparative study of European and American manufacturing methods with special reference to Bicheroux process and methods developed by Libbey-Owens-Sheet-Glass Co., Henry Ford Motor Co., Pittsburgh Plate Glass Co., and General Motors Co.

H

HYDRAULIC TURBINES

Design. Graph for Quick Determination of Principal Dimensions of Hydraulic Turbines (Graphique pour la détermination rapide des dimensions principales des roues de turbines hydrauliques), M. Mathieu. Arts et Metiers (Paris), no. 116, May 1930, pp. 200–202. 1 fig. Graph and explanatory note are given.

Flow. Mitteilungen des Instituts fuer Stro emungsmaschinen der Technischen Hochscule Karlsruhe, heft 1. Edited by W. Spannhake. Munich and Berlin, R. Oldenbourg, 1930. 85 pp., illus., diagrs., 8.-r.m. First number of new serial devoted to work of Institute which is primarily interested in investigation of turbo-machinery; description of equipment for investigating turbines and pumps, and reports on one purely theoretical and two experimental investigations; two of latter deal with theoretical potential flow through turbine wheel and its comparison with actual flow; construction and use of new apparatus for measuring forces on blades of turbine. Eng. Soc. Lib., N. Y.

Maintenance and Repair. Turbine and Generator Overhaul Reveals Peculiar Troubles, M. M. McIntire. Elec. World, vol. 95, no. 24, June 14, 1930, pp. 1220–1221, 1 fig. Three 5000-kva. hydroelectric units at Don Pedro plant of Turlock and Modesto (California) irrigation districts brought to light some interesting conditions and developed methods of repair which may prove of interest to other operating engineers faced with similar problems.

I

INDUSTRIAL MANAGEMENT

A.M.A. Papers. Good Management Required at Top. Iron Age, vol. 125, no. 21, May 22, 1930, pp. 1544–1545. Review of papers presented before American Management Association on: Organization of Managing Group, M. C. Rorty; Principles of incentives for executives, J. P. Jordan; Management developments in Western Electric Co., C. G. Stoll; Some public relations worth cultivating, D. Lawrence.

Education. Training Future Business Leaders, C. S. Coler. Iron Age, vol. 125, no. 24, June 12, 1930, pp. 1741–1744, 2 figs. Description of training methods for executive and engineering personnel of Westinghouse Electric and Mfg. Co.; blank form of student's training record is given; principles of holding good men in organization.

Manufacturing Program. Speed and Output Take Care of Themselves—Interest Workers in Profits, F. C. Lewman. Factory and Indus. Mgmt., vol. 79, no. 6, June 1930, pp. 1337–1339, 4 figs. Manufacturing program of Richman Brothers Co., Cleveland, garment manufacturers, based on morale among employees; work is so organized that it is easier to turn out quantity of work than not to.

IRON AND STEEL PLANTS

Waste Heat Utilization. The Utilization of Waste Heat in the Steel Industry, C. W. E. Clarke. Fuels and Furnaces, vol. 8, no. 6, June 1930, pp. 827–830. Discussion of practical possibilities for utilization of waste heat in steel plant; sources of waste heat; quantities of various gases; use of blast-furnace gas in conjunction with pulverized coal; various heat requirements. Abstract of paper read before Am. Iron and Steel Inst., previously indexed from Advance Paper, for mtg. May 9.

L

LOCOMOTIVES

Design. Railway Motive Power, a Few Points on the Present Trend of Design, W. E. Barnes. Can. Ry. and Mar. World (Toronto), no. 388, June 1930, pp. 352–354. Discussion of problems encountered by locomotive designer; design features of various locomotive parts are considered.

Fuel Economy. Fuel Association Work Commended by Railroad Officers. Ry. Mech. Engr., vol. 104, no. 6, June 1930, pp. 325–329, 2 figs. Chicago convention told that savings through fuel economy are largely offset by increased taxes, committee reports concerning new locomotive economy devices, and Diesel locomotives.

High Pressure (Loeffler). The Loeffler Locomotive Boiler, Fuchs. Eng., and Boiler House Rev. (Lond.), vol. 43, no. 11, May 1930, pp. 700, 703, 704, and 707. Great advantage of system is that water is vaporized in unheated boiler drum; heat produced on grate is delivered indirectly by current of superheated steam; system of Schwartzkopff-Loeffler locomotive is shown; locomotive is developed as three-cylinder compound with two outside high-pressure cylinders of 220-mm. diam. and low-pressure cylinder to 600-

mm. diam. placed between pipes; economy of coal of 47 per cent was theoretically calculated compared with modern locomotives.

LUBRICANTS

Graphite Graphite Greases (Grasas grafitadas), C. F. Hickethier. Ingenieria (Buenos Aires), vol. 34, no. 5, May 1930, pp. 178–180. Graphite is most important solid lubricant; it is used in natural state and in combination with oils or lubricating greases; analyses of typical natural graphites, and of Acheson artificial amorphous graphite; graphite grease specifications.

Oils and Greases. Lubricating Oils, Greases, and Cutting Oils, J. S. Gander. Mech. World (Manchester), vol. 87, no. 2264, p. 483. Essential properties of lubricating oils are: body to prevent metallic surfaces from coming into contact; should be as fluid as possible and have minimum coefficient of friction; freedom from corrosive acids; contain no materials liable to produce oxidation or gumming; must not be easily thinned by the heat or thickened by the cold.

M

MACHINE TOOLS

Advantages. Machine Tools From the Manufacturing User's Point of View, C. Armitage. Mech. World (Manchester), vol. 87, no. 2261, May 2, 1930, pp. 413–415, 1 fig. Disadvantages of present type of milling machines; chucking capstans and turret lathes; advantages of hydraulic spindle drive; electric welding machines; chucking automatics; future development; condensed outline of advantages and disadvantages of multiple operation machine; single operation machines and individual motor drives.

Electric Drive. Recent Developments in Electric Drives of Machine Tools on the Continent. Machy. (Lond.), vol. 36, no. 925, July 3, 1930, pp. 444–447, 5 figs. Control system for large lathe; electric drive for portal milling machine; electrical control arrangements for heavy boring and turning mill; turning and grinding machine for large rotors employing 13 motors; electric drive of planers.

Obsolescence. Determining the When and Why of Machine Tool Replacement, J. R. Weaver. Am. Mach., vol. 72, no. 26, June 26, 1930, pp. 1013–1015. Values of permanent survey of machine-tool equipment with annual revision.

MATERIALS HANDLING

Equipment. Bucket Elevators, Bucket Hoists, and Belt Conveyors (Skopelevatorer, Skophissar och remtransportorer), E. Dahlin. Teknisk Tidskrift (Stockholm), vol. 60, no. 20, May 17, 1930 (Mekanik), pp. 61–67, 6 figs. Bucket elevators and conveyors are discussed; applications, efficiency and cost of construction and installation.

METALS

Corrosion. Corrosion and Stress. Metallurgist (Supp. to Engineer, Lond.), June 1930, pp. 82–93. Emphasis is laid on importance of fact that stress is important factor in regard to corrosion; perhaps most striking evidence in that direction is associated with what has come to be known as corrosion fatigue following upon original discovery made by Haigh and subsequently very fully worked out by McAdam, that fatigue resistance of great majority of metals and alloys becomes very seriously reduced if surface of test piece is exposed to such mildly corrosive conditions as are produced by gentle stream of tap water.

Fatigue. Fatigue and Fatigue Testing. Metallurgist (Supp. to Engineer, Lond.), May 1930, pp. 75–76. Review of discussion on impact testing by A. Thum and S. Berg, previously indexed from V.D.I. Zeit., Feb. 15, 1930, under classification of Impact Testing, Notched Bar. Question of fatigue under impact is regarded in Germany as very real one; danger of blows is believed to be increased when they occur at high frequency as is case with fast-running machines, and it is supposed that they may lead to serious shortening of life of machine.

N

NITRIDATION

Homo Method. Nitrogen Case-Hardening of Steel by The Homo Method. Metallurgia (Lond.), vol. 2, no. 7, May 1930, pp. 32 and 36, 1 fig. Nitridation process is stated by anonymous author as being commonly referred to as "nitration;" no nitrates are used and none are formed, but process consists in subjecting machined, and preferably heat-treated, articles to ammonia gas under certain conditions, resulting in remarkable surface hardness being imparted without any further heat treatment; development is credited to A. Fry; description of furnace equipment and practice.

NOISE

Measuring Instruments. The Analysis and Measurement of Noise Emitted by Machinery, B. A. G. Churcher and A. J. King. Instn. Elec. Engrs.—Jl. (Lond.), vol. 68, no. 402, June 1930, pp. 780–787. Discussion of paper previously indexed from Jan. 1930, issue of same journal.

P

PETROLEUM INDUSTRY

United States. Stabilization of American Oil Industry, J. E. Jones. Pan-Am. Geologist, vol. 53, no. 3, Apr. 1930, pp. 183–196, 1 fig. Analysis and discussion of situation with respect to crude oil supply and demand in United States; tabular statistical data, Jan. 1916 to Dec. 1929; fundamental factors, or bases, of determining supply and demand are domestic production, imports, exports, and stocks; domestic overproduction is regarded as myth, except for short periods and locally; over supply exists primarily because of imports; remedy is suggested.

PIPE LINES

Protective Coatings. Procedure in Making Surveys of Soils, D. E. Dickey and H. Hayes. Oil and Gas Jl., vol. 29, no. 3, June 5, 1930, p. T-75, 2 figs. Brief review of literature on research on pipe-line corrosion; outline of practice of oil company in California in soil survey and final selection of coatings for portions of line requiring protection. Bibliography.

Welding. Electric Arc Welding of Pipe Lines, C. M. Taylor. Oil and Gas Jl., vol. 29, no. 3, June 5, 1930, pp. T-76 and T-79, 1 fig. Brief review of development since introduction of electric arc welding in pipe-line industry about two years ago; explanation of approved practice; bell and spigot joints; firing-line and bell-hole units; river crossings.

POWER PLANTS

Design. Modern Power—Basic Principles, Design and Application, F. T. Morse. South Power Jl., vol. 48, no. 6, June 1930, pp. 41–47, 8 figs. Discussion of problems developed in electric power generation and distribution by variable load which is characteristic of all public-utility systems; careful explanation of various terms used is given, and methods employed by leading utilities in meeting various problems are discussed.

Equipment. Station A, Twenty Years Later. Power, vol. 71, no. 25, June 24, 1930, p. 988, 2 figs. Evolution of power-generating equipment between 1910 and 1930 as seen in comparison of units in San Francisco Gas and Electric Co. station.

Steam and Diesel Combined. Joint Use of Diesel and Steam Engine to Balance Heat and Power, E. J. Kates. Am. Soc. Mech. Engr.—Advance Paper for Nat. Oil and Gas Power mtg., June 12–14, 1930, 14 pp., 6 figs. Purpose is to increase efficiency of steam utilization; simplified examples are used to show effect of Diesel power on overall thermal economy and upon overall costs; conclusions of two specific studies of heat and power supply involving joint use of Diesel and steam engines, and brief description of two actual applications.

PRESSURE VESSELS

Welding. The Strength and Design of Fusion Welds for Unfired Pressure Vessels, L. W. Schuster. Mech. World (Manchester), vol. 87, nos. 2264, 2267 and 2268, May 23, 1930, pp. 484–487, June 13, pp. 551–553, and June 20, pp. 585–588, 12 figs. Abstract of paper presented before Instn. Mech. Engrs., previously indexed from Engineering, Mar. 14, 21, and 28, 1930.

PULVERIZED COAL

Firing With. Evolution of Pulverized-Coal Firing in France Since 1921 (L'évolution du chauffage au charbon pulvérisé en France depuis 1921), P. Frion. Chaleur et Industrie (Paris), special number, Apr. 1930, pp. 89–97. Development and improvements of pulverized-coal firing in France; preparation, washing, drying, etc.; grading and handling; various uses; combustion process and chambers; removal of ashes.

PUMPS, CENTRIFUGAL

High Capacity. Development of Storage Pumps (Der Entwicklungsstand der Speicherpumpen), W. Hahn. V.D.I. Zeit. (Berlin), vol. 74, no. 25, June 21, 1930, pp. 881–886, 15 figs. General discussion of functions, design, and installation of large-capacity pumps for pumped storage power plants with special reference to Herdecke hydroelectric plant; tests with models; special features of Herdecke pump; station equipped with two-stage adjustable guide vane centrifugal pump having capacity of 13.16 cu. m. per sec., working against total head of 160 m. with speed of 300 r.p.m.

R

ROCKET PROPULSION

Experiments. Wege zur Raumschiffahrt, H. Oberth. 3d edition of Die Rakete zu den Planetenraeumen. Munich and Berlin, R. Oldenbourg, 1929, 431 pp., illus., plates, diagrs. 20-r.m. Author has rewritten his interesting book which presents results of his experimentation upon rocket flight; rockets may be used, he says, for meteorological investigations of upper atmosphere for aerial photography and surveying, for postal communication, for airplane propulsion and for interplanetary flight; book discusses scientific and engineering problems, structural details of rockets, and various other questions involved. Eng. Soc. Lib., N. Y.

S

SMOKE ABATEMENT

Discussion. A Catalyst, A. E. Winter. Coal and Coal Trade Jl., vol. 61, no. 22, May 29, 1930, p. 347. Correspondence item on use of catalyst for increasing sales by treating coal for prevention of soot, smoke, and clinker; discussion of combustion and cause of smoke; possibilities in partial elimination of smoke by catalytic treatment of coal.

Experiments. Use of Purified Flue Gases in Carbon-Dioxide Fertilizer (Die Verwendung von gereinigten Rauchgasen zur Kohlensaeuereduengung), F. Riedel. Gesundheits-Ingenieur (Munich), vol. 53, no. 17, Apr. 26, 1930, pp. 257–261, 6 figs. Discussion of beneficial effects of carbon-dioxide fertilizing; results of experiments in large green houses and in open fields; bearing of method upon smoke abatement; carbon-dioxide fertilization may eliminate damage caused by smoke and may cause high yields of crops.

Papers at Dortmund. Praktische Ergebnisse auf dem Gebiete der Flugasche Beseitigung und Staubmessung, by Fachausschuss fuer Staubtechnik beim V.D.I. Berlin, V.D.I. Verlag, 1930, 40 pp., illus., table, 4.-r.m. Five papers presented at meeting of engineers and others interested in dust and smoke problem, held at Dortmund in past winter; one paper deals with shape of dust and ash particles; two articles describe experience with apparatus for measuring flue dust; remaining two papers deal with results obtained in two large installations for removing dust from flue gases. Eng. Soc. Lib., N. Y.

SPRINGS

Design. General Considerations in Designing Mechanical Springs, A. M. Wahl. Machine Design, vol. 2, no. 5, May 1930, pp. 26–31, 12 figs. Outline of method for determining working stresses in spring based on tensile and fatigue properties of material; graphs show distribution of stresses over cross section of springs of large index and results of stress test on helical spring; numerical example for valve spring is given.

Features. Spring vs. Weights, R. G. Standerwick. Gen. Elec. Rev., vol. 33, no. 6, June 1930, pp. 341–344, 5 figs. Author points out limiting features of dead weights and describes how these limits restrict their useful application in many cases; interesting features of springs and some of general laws.

STEAM

High Pressure. Steam Conditions and Cycles, J. N. Waite. Elec. Rev. (Lond.), vol. 106, no. 2740, May 30, 1930, pp. 1003–1005. Case for high initial temperatures, high pressures, and resuperheating in electric power stations.

Higher Steam Pressures and Temperatures. Nat. Elec. Light Assn.—Report, no. 053, May 1930, 8 pp., 5 figs. Report discusses thermal

economies resulting from use of steam pressures between 500 and 1500 lb., and of steam temperatures above 750 deg. fahr.; construction costs and operating results in their relation to steam conditions, and properties of various alloys at high temperatures.

STEAM ACCUMULATORS

Ruths. Ruths' Storage Equipment for Peak-Load Power Generation in Berlin (Ruthsspeicher fuer Spitzenkrafterzeugung in Berlin), E. Schulz and Gropp. Elektrizitaetswirtschaft (Berlin), vol. 29, no. 505, Apr. 1, 1930, pp. 153–162, 16 figs. Ruths storage equipment of Charlottenburg plant of Berlin municipal electricity works is described; notes on dimensions; possibilities of equipment; method of operation; reliable experience for future developments; costs.

STEAM CHARTS

For Steam Cycle. The Heat Content-Pressure Diagrams, L. Holdredge. South. Power Jl., vol. 48, no. 6, June 1930, pp. 56–59, 1 fig. Diagram intended to cover complete steam cycle, much broader range than does Mollier diagram, in solution of thermo-dynamic problems; its use offers easy graphical methods of determination.

STEAM CONDENSERS

Design. Condenser Design and Operation, A. J. German. Pac. Mar. Rev., vol. 27, no. 6, June 1930, pp. 232–233. Progress in condenser design during past few years has been directed along following lines: first, better steam distribution over tube nest, thus making larger percentage of tube-surface area effective in heat transfer; second, removal of non-condensible gases by better arrangement of baffles and lanes.

Surface. Study of Circulating Water Consumption in Surface Condensers (Etude sur la consommation d'eau de circulation dans les condenseurs par surface), A. Risler. Revue d'Electricité et de Mécanique (Paris), no. 10, Mar./Apr. 1930, pp. 38X-41X, 1 fig. Mathematical data, curves, and tables.

STEAM POWER PLANTS

Ash Handling. Ash Handling at Brighton. Elec. Times (Lond.), vol. 77, no. 2013, May 22, 1930, pp. 1023–1024, 3 figs. Cleanliness, simplicity, and efficiency of Hydrojet system of ash handling and disposal outlined with installation at Brighton Power Station taken as example.

Ash Separators. Recovering Unburnt Fuel From Ash Pit Refuse, D. Brownlie. Combustion, vol. 1, no. 11, May 1930, pp. 40–44, 6 figs. Recovery of unburnt fuel from ash-pit refuse has been practiced to considerable extent in Great Britain and in certain European countries; in England, practice seems to have found particular application in connection with gas-plant operation; author describes two of most extensively used processes and presents data relative to economic aspects of typical gas-plant and steam-plant installations.

Coal Handling. Coal and Ash Handling Plant at the Maidstone Power Station, G. F. Zimmer. Mech. Handling (Lond.), vol. 17, no. 5, May 1930, pp. 139–142, 2 figs. Historical development of coal handling and power plant; plan and two elevations of ash-handling installation; ash-handling plant; Bennis submerged conveyor; elevator conveyor.

Design. Steam Generation and Utilization, L. C. Edgar. Assn. of Iron and Steel Elec. Engrs.—Proc. for Yrs. 1928–1929, pp. 697–698. Indexed in Engineering Index 1929, p. 1739, from Iron and Steel Engr., June 1929.

Efficiency. Comparison of Steam Station Performance, A. G. Christie. Power Plant Eng., vol. 34, no. 12, June 15, 1930, pp. 672–675, 4 figs. Presentation of expression for station performance and comparison; discussion of question and problems arising from new method of expressing station performance; "Parsons Line" does not consider capacity factor, which has many advantages; input-output curves for three phases of large coal-fired central station are given.

Instrument Control. Instruments, Automatic Control and Plant Records. Elec. West, vol. 64, no. 6, May 15, 1930, pp. 443–446, 1 fig. Prime Movers Committee Report giving descriptive data and operating experiences with certain types of automatic-control equipment in use on Pacific Coast, i.e., automatic combustion-control equipment; system of remote control of gas-pressure regulators and feedwater regulation.

Lignite Fired. Use of Exhaust Steam From Power Stations, D. Brownlie. Eng. and Boiler House Rev. (Lond.), vol. 43, no. 9, Mar. 1930, pp. 531–534, 3 figs. Description of Boehlen plant operation of Aktiengesellschaft Saechsische Werke of Dresden, which utilizes exhaust steam from number of turbines in manufacture of lignite briquet, so that equipment consists of combined power station and briquetting factory under one control.

Operation. Operating and Maintenance Practice. Elec. West, vol. 64, no. 6, May 15, 1930, pp. 446–450, 3 figs. Prime Movers Committee Report giving data relative to maintenance costs and operating experiences with boilers, furnaces, turbines, condensers, and miscellaneous auxiliaries; questionnaires were sent to member companies and replies received have been arranged into form most suitable for future reference.

STEAM TURBINES

Blades of Monel Metal. Monel Metal (Monel-Metall), A. Schulze. Waerme (Berlin), vol. 53, no. 18, May 3, 1930, pp. 334–337, 8 figs. Discussion of its thermal and mechanical properties, and its thermotechnical applications, with special regard to its use in steam-turbine blades.

STEAMSHIPS

Turbine (Europa). Express Liners, T. E. Ferris. Mar. Eng. and Shipg. Age, vol. 35, no. 7, July 1930, pp. 350–357 and 381, 18 figs. Architectural features of vessel, descriptions of which have been previously indexed from various sources.

STEEL

Heat Treatment. The Structure of Heat-Treated Low Carbon Steel, W. J. Crook and H. S. Taylor. Metals and Alloys, vol. 1, no. 12, June 1930, pp. 539–543, 4 figs. Study of physical properties; structural changes which take place when steel containing about 0.20 per cent carbon is quenched from just above upper critical point and subjected to various draw temperatures; microstructures of steel heat treated on commercial scale; curves and microphotographs illustrate results of experiments.

Tinning of. Hot Tinning Steel, Wrought, Cast and Malleable Iron Parts, C. H. Proctor. Metal Cleaning and Finishing, vol. 2, no. 7, July 1930, pp. 593–594. Data for application of molten tin on steel and wrought, cast and malleable iron parts.

STOKERS

Underfeed. Automatic Heat With Solid Fuels, N. Cunningham. Heat. and Vent., vol. 27, no. 7, July 1930, pp. 73–77, 4 figs. Advantages and disadvantages of various types of anthracite stokers and burners; power required depends on coal-feed capacity; approximate cost of anthracite-burning equipment.

T

TANKS

Sand Blasting. Cleaning of Inner Surfaces of Tender Water Tanks With Sand Blast (Innenreinigung von Tenderwasserkaesten mit Sandstrahl), Niederstrasser. Organ fuer die Fortschritte des Eisenbahnwesens (Berlin), vol. 85, no. 1, Jan. 1930, pp. 13–14, 5 figs. Details of special sand-blast outfit manufactured by Benno Schilde of Hersfeld; 6.5 hp. blower operates at 2880 r.p.m. and has air capacity of 40 cu. m. per min.

TEXTILE MACHINERY

Electric Drive. The Electrical Drive of Weaving Sheds Equipped With Plain Cotton Looms, R. H. Wilmot. Metropolitan Vickers Gaz. (Manchester), vol. 12, no. 205, Apr. 1930, pp. 85–90, 2 figs. Advantages and disadvantages of various methods of driving weaving sheds; cleanliness of product and atmosphere; description of modern methods of electrical drive of weaving sheds.

TOOL STEEL

Hardening. Improvement of Hardness of Normally Heat-Treated Cutting Tools by Cold Hardening (Die erhoehung des haertegrades normal gehaerteter Schneidwerkzeuge durch Kaltverfestigung), E. Franke. Werkstattstechnik (Berlin), vol. 24, no. 13, July 1, 1930, pp. 360–362, 2 figs. Description of new surface cold-hardening procedure; graphs show hardness increase for various steels; untreated portion of carbon steel shows Brinell hardness 740, while surface shows hardness of 1020 notes on electromagnetic hardening methods.

TUBES

Seamless. The Piercing Action in the Manufacture of Seamless Tubes, K. Simoneit. Rolling Mill Jl., vol. 4, no. 7, July 1930, pp. 375–378, 2 figs. Functions of mandrel, strain on same, and effects of pass adjustment on piercing action in Stiefel mills.

TUNGSTEN CARBIDE

Cutting Tools. Users of Tungsten Carbide Report Variety of Experiences, F. C. Spencer. Iron Trade Rev., vol. 86, no. 25, June 19, 1930, pp. 73–75. Advantages and shortcomings are revealed by replies to questionnaire of subcommittee on tungsten-carbide cutting materials of American Society of Mechanical Engineers; suggestions for improvement in machine-tool design.

V

VIBRATIONS

Damping. Steady Forced Vibration as Influenced by Damping, L. S. Jacobsen. Am. Soc. Mech. Engrs.—Advance Paper no. 12, for mtg. June 9 to 12, 1930, 10 pp., 11 figs. General method of obtaining approximate solutions of steady forced vibration of damped system, of one degree of freedom, for case of sinusoidally varying disturbing forces; approximation consists in expressing all damping terms of original differential equation by single equivalent damping term, proportional to first power of velocity of motion; discussion of experimental results at Stanford University; comparison of Den Hartog's exact theory and the approximate theory.

W

WAGES

Payment Plans. Bedaux Methods (Das Bedaux-Verfahren), G. Schlesinger. Werkstattstechnik (Berlin), vol. 24, no. 12, June 15, 1930, pp. 325–330. Detailed discussion of various aspects of Bedaux methods; this system is based on measurement and classification of work, incentives for employees, and shop management. Bibliography.

WATER PIPE LINES

Welding. Two Interesting Failures of Welded Patches on Large Steel Pipe, W. W. Brush. Water Works Eng., vol. 83, no. 14, July 2, 1930, pp. 1013–1014, and 1052, 3 figs. Causes of failure of two coupon patches afterward changed to welded form.

WATER SOFTENING

United States. Progress and Trends in Water Softening, C. P. Hoover. Eng. News-Rec., vol. 104, no. 21, May 22, 1930, pp. 843–846, 5 figs. Review of recent progress; greater degree of softening now obtained; excess-lime method followed by carbonation; combination of zeolite and lime-soda softening; chemistry of water softening; pneumatic conveying equipment for handling of chemicals; carbonation plant at Columbus, Ohio; continuous sludge-removal equipment at St. Louis, Mo.; lime feeders and slakers at Marion, Ind. See editorial comment, p. 832.

WELDING

Applications. Salvaging Expensive Parts, A. Eyles. Welding Engr., vol. 15, no. 5, May 1930, pp. 45–46, 11 figs. Description of procedure for typical welding repair jobs; use of fluxes in welding and its alloys; welding ruptured copper steam pipe; gas welding cast-iron parts; rivet-heater electrodes built up by welding.

WELDERS

Training. The Training of Operators in the Welding and Cutting Industries, J. Ryder. Machy. Market (Lond.), no. 1545, June 13, 1930, pp. 23–24. Need for expert operations; qualifications of good welder. Lecture delivered before Instn. Welding Engrs.

WELDS

Properties. Control of Weld Properties, R. W. Holt. Fusion News, vol. 2, no. 1, July 1, 1930, pp. 9–10 and 14, 4 figs. Discussion and diagrammatic representation of interrelationship of various factors affecting weld properties.

WOODWORKING MACHINERY

Details. Hand-Feed Planing and Jointing Machine. Engineering (Lond.), vol. 129, no. 3360, June 6, 1930, p. 748. Details of 9-in. planer and jointer reintroduced by Wadkin and Co.; besides ordinary surface planing, such operations as making glue joints, planing out of wind, molding, tonguing, grooving, tapering, beveling, chamfering, and stop chamfering, can be done as readily as on larger machines.

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IN TWO SECTIONS—SECTION TWO

MECHANICAL ENGINEERING

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Railway Electrification

WHEN a non-engineer acquaintance who has just completed a smoky trip behind a steam locomotive asks you why all railways are not electrified, what do you tell him? Can you get beyond the obvious obstacle of investment costs and the vague statement that the economic problems are complex?

R. B. Morton, project engineer for Gibbs and Hill, who make a specialty of railway electrification, discussed features of the economics of this phase of the transportation problem before the Bridgeport, Conn., section of the A.S.M.E. His paper is the leading article in the September issue of MECHANICAL ENGINEERING.

There are about 1900 miles of electrified route in the United States—three-quarters of one per cent of the total of 250,000 miles of steam railways—representing 4200 track miles, with an equipment of about 465 electric locomotives and 2750 multiple-unit cars. Since 1923 electrification has proceeded at the rate of about 200 track-miles per year, but considering present projects under development, authorized, or announced, it seems probable that it will go forward at a more rapid rate during the next decade.

The Engineer's Influence

RALPH E. FLANDERS, known to engineers and industrialists as manager of the Jones and Lamson Machine Company and to the world at large as the author of the very excellent opening chapter of the symposium, "Toward Civilization," published this year by Longmans, Green and Company, thinks a great deal and writes too infrequently about the relations of the engineer to civilization and society. Last April, at a dinner given in Washington to the engineers of the world who had been awarded the A.S.M.E. Fiftieth Anniversary Medal, Mr. Flanders discussed the work and influence of the engineer with these distinguished medalists. His address appears in the September issue of MECHANICAL ENGINEERING. The time is ripe, says Mr. Flanders, for an application of the engineering viewpoint to the social machine. As he expresses it in private conversation, it is time for persons with an engineering viewpoint to "manhandle civilization." Evidences of what may be accomplished are to be found in President Hoover's handling of the Mississippi Valley flood problem, in his prompt action to stabilize industrial conditions and prevent unemployment when depression followed the stock-market crash of last fall, and in his equally prompt and constructive attention to the situation occasioned by the recent drought in agricultural communities.

"The provision of an adequate surplus of food, clothes, the materials of shelter, and innumerable other material goods is the unquestioned achievement of the engineer," asserts Mr. Flanders. "With proper distribution—not yet attained—this surplus is capable of yielding desirable things or fruitful leisure to every member of a properly balanced industrial society."

Mr. Flanders' thesis transcends the immediate and technical aspects of engineering. It concerns the common welfare of mankind, and, idealistic as it is, it sets a goal toward which to strive. The engineer has provided the material means by which this ideal may be attained. Through the application of his methods may yet come the solution of the more subtle economic and sociological problems that still bar the way.

"Carrying the Load"

TO THOSE on the outside there is something of romance in sticking at the job and seeing it through, in spite of all odds, be it on a ship at sea, in running a railroad, winning a war, or even in keeping the juice on the wires of a central-station power plant. To those on the inside, as Mr. Alex D. Bailey, superintendent of generating stations of the Commonwealth Edison Company, says in his article, "Carrying the Load," in the September issue of MECHANICAL ENGINEERING, there is much "drudgery, sweat, and profanity."

It is a serious responsibility, as all will admit, to maintain the continuous and efficient operation of any public utility. It takes brains and money—a lot of both—to do it successfully but all over the civilized world little groups of technicians are maintaining the numerous public services upon which modern life depends. Let them shirk their tasks or quit their jobs and confusion and untold hardship result.

Specifically, Mr. Bailey discusses the problems, common to all central electricity-supply systems, of the Commonwealth Edison Company of Chicago, and the manner in which they are attacked. Careful study and planning in advance are necessary to carry the load successfully. "The performance of today," says Mr. Bailey, "is the result of work done years ago, and our reputation in the future will be governed by our ability to take care of our emergencies in advance, and to anticipate in every way the requirements of the service." Black as public utilities may be painted by politicians and demagogues, their operating and engineering departments demand as much respect as do any other human institutions.

Statistical Engineering

IT WAS a happy day for scientists when they held with smug assurance that every phenomenon, whether considered in the large, or in its infinitesimal elements, behaved according to fixed and fairly simple laws of nature. But Einstein and Heisenberg and a host of others came along with disturbing theories of relativity and exception,

which, if they were enlightening to some, were confusing to others.

With our Gargantuan or macroscopic senses, we know matter as a crowd, not as individuals forming that crowd. Because the crowd seems to be moving in a certain direction, or sending forth a roar of uniform pitch, we do not realize that the individuals comprising it are wandering about in every conceivable direction and are shouting every possible note of the scale.

So it is with a material, or with such a process as radiation. A piece of steel looks homogeneous enough. Even if we divide it into a great number of pieces and examine every one of them, the pieces still seem identical in composition and physical properties. But continue the division until microscopical pieces result and we begin to notice differences in composition and properties. The assumed homogeneity becomes a myth, and we infer that what we had observed previously was a sort of average of innumerable individual states, a statistically probable state.

The same results may be obtained with phenomena involving energy, as, for instance, that of radiation in a combustion process. There is, at a given instant, a vast aggregation of incandescent molecules forming the products of combustion from which energy is being radiated. Heat, we say, is passing from this mass of gases to the surrounding furnace walls. This is a vague expression of the mechanism of radiation, although sufficiently satisfying if we think of the gas in terms of the mass—the crowd—or, as we say, macroscopically. But if we attempt a microscopic picture of the individual particles of combustion products at high temperature and the energy radiation from them, assuming the mechanism to be that proposed by Planck and taking the form of bits of energy, called quanta, shot out with the speed of light from those individual particles of gas, then everything is different. Now we find that each quantum must be a whole quantum, and that its magnitude is the product of two factors, one a constant, and the other the frequency of vibration. For quanta of different magnitude, therefore, only the frequencies can be different, and, as the frequencies vary, we have phenomena which we interpret as heat, the infrared rays, as light, the visible rays, or as X-rays, the very high frequency rays capable of extraordinary penetration.

How then do we interpret the macroscopic or mass result of these emanations of quanta having individually different frequencies? Merely that we can prove mathematically what we know to be a fact, that it is statistically probable that there are more frequencies within the infrared or heat range than in any other.

Two papers in the September issue of MECHANICAL ENGINEERING illustrate the use by engineers of the statistical method. Fred B. Seeley, professor of theoretical and applied mechanics at the University of Illinois, writes on "The Statistical Element in Mechanics of Materials." Walter J. Wohlenberg, Sterling professor of mechanical engineering at Yale University, makes use of the method in a paper, only the first part of which appears this month, entitled "Combustion Radiation and the Planck Quantum Theory."

As if these papers were not sufficient evidence that engineers are making use of the methods of mathematical physicists, word comes from Stevens Institute of Technology that, in its newly organized graduate studies, Dr. W. A. Shewhart, of the Bell Laboratories, will give a course on the use of the statistical method in such manufacturing problems as the inspection of large quantities of duplicate parts. Engineers are always treading the skirts of Science.

An Aeronautic Library

DR. ALBERT F. ZAHM of the Library Congress, in the September issue of MECHANICAL ENGINEERING, tells about what is probably the most remarkable and extensive collection of books and pamphlets on aeronautics in existence. It is in the Library of Congress and was made possible by the grant of $140,000 from the Daniel Guggenheim Fund for the Promotion of Aeronautics.

Safety in Aerial Navigation

HOW the radio has made aerial navigation safer is the subject of a paper by Edmund T. Allen, test pilot and research engineer of the Boeing Airplane Co., in the September issue of MECHANICAL ENGINEERING. Mr. Allen tells about directive radio beacons by means of which the pilot can keep accurately on his course regardless of visibility, about the radio compass, and about radio triangulation for determining geometrically the exact location of an airplane on a map. He also tells how the broadcasting of weather information helps pilots to know what to expect in the way of weather conditions on their flights, and how two-way voice communication makes it possible for pilot and dispatcher to keep in touch with one another at all times.

Synthetic Lumber From Cornstalks

IN MEDIEVAL times, the alchemists diligently sought, but never found, the secret of turning the baser metals into gold. Modern chemists, to whom the world owes an incalculable debt, perform humbler miracles by creating new materials of extraordinary properties with some of the most unpromising ingredients. Specify the properties you require to a good chemist and he will combine a few common substances lying about his laboratory and give you what you want. Or suggest to him that you have a lot of waste and worthless by-product and he will convert it into something new, useful, and valuable. This is what has been done with cornstalks at the Iowa State College.

In the September issue of MECHANICAL ENGINEERING, O. R. Sweeney and Robley Wilfrey of the Iowa State College tell how synthetic lumber is made from cornstalks and corncobs. They are able to produce a material as dense and hard as teakwood, or as tough and strong as lignum-vitae. These materials can be made in sheets of different thicknesses, or can be pressed into finished shapes, such as doors and window frames.

By other processes they can make acoustic board, and material for sound or heat insulation, with properties superior to those of natural products used for these purposes, and they can also produce an excellent substitute for cork. This may not be making gold out of lead, but it has interesting and far-reaching possibilities, and, best of all, it can be done.